Horticulture Collaborative Research Support Program

Annual Report 2012-2013

Horticulture CRSP Annual Report 2012-13

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Partners: Cornell University, North Carolina State University, University of Hawai'i at Mānoa, and University of California, Davis (management entity)

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Management entity information

The Horticulture Collaborative Research Support Program (CRSP) builds international partnerships for fruit and vegetable research that improves livelihoods in developing countries. The Horticulture CRSP is managed by a team at the University of California, Davis, in the College of Agricultural and Environmental Sciences, under the Department of Plant Sciences with support from the International Programs Office. Horticulture CRSP has been funded by the U.S. Agency for International Development (USAID) since October 2009.

The partnerships we support cross borders to strengthen horticultural value chains. Horticulture CRSP projects provide critical information for development professionals on how to better enrich diets and increase incomes. Horticulture - —growing fruits and vegetables—provides critical nutrients for a balanced diet. Not eating enough fruits and vegetables is a major factor in some of the world's most widespread and debilitating nutrient-related disorders. Farmers growing high-value crops, such as fruits, vegetables, flowers or herbs, consistently earn more than those growing other commodities. Horticulture can be an engine for agricultural and economic diversification. All Horticulture CRSP projects include aspects of gender equity, improved information access, and technological innovation.

In the past four years, we have supported 40 research projects with 15 U.S. universities and over 100 organizations. The Horticulture CRSP management entity is located at University of California, Davis. Our team is comprised of the following personnel:

Leadership

Elizabeth Mitcham, Director

Dr. Elizabeth (Beth) Mitcham is a postharvest biologist and extension specialist with the Department of Plant Sciences at UC Davis. Her research program is focused on maintaining the quality of fruit after harvest, mechanisms of calcium deficiency in fruit, and postharvest insect control.

Amanda Crump, Associate Director

Amanda Crump leads the gender equity and monitoring and evaluation programs. Her research interests include the development of novel agricultural extension education practices that impact farmers, particularly women.

Michael Reid, Leader of Implementation of Innovative Technology and Special Projects

Dr. Michael Reid is a professor and postharvest extension specialist emeritus in the Department of Plant Sciences. Specializing in postharvest handling of ornamentals, he has worked with flower growers in Africa, Latin America and Asia. He was recently inducted into the California Floriculture Hall of Fame.

Mark Bell, Leader of Communications and Information Transfer

Dr. Mark Bell is also the director of the UC Davis International Learning Center. Before joining UC Davis, he was head of both International Programs and the Training Center at the International Rice Research Institute (IRRI) in the Philippines.

Accounting and fiscal management

Heather Kawakami, Budget Analyst

Heather Kawakami is also the business unit manager for the Department of Plant Sciences.

Sara Saberi, Budget Analyst

Sara Saberi is also an account manager in the Department of Plant Sciences.

Programmatic and administrative support

Britta Hansen, Regional Centers of Innovation Specialist

Britta Lilley Hansen holds a master's degree in Development Practice. She previously worked in nutrition research at the University of Minnesota and has served with the Peace Corps in Liberia and Bolivia.

Diana Puccetti, Office and Event Planning Assistant

Diana Puccetti is a Certified Government Meeting Planner (CGMP). She is currently pursuing a B.S. in Technical Management and has previously worked in municipal government.

Brenda Dawson, Communications Coordinator

Brenda Dawson has communicated on behalf of the UC Small Farm Program, UC Division of Agriculture and Natural Resources, and UC Davis University Communications. She previously worked as a newspaper editor.

International Programs Office

Jim Hill, Associate Dean

Dr. Jim Hill is the associate dean of the UC Davis College of Agricultural and Environmental Sciences.

Chelo Abrenilla, Analyst / Supervisor

Rachel (Chelo) Abrenilla provides support to Horticulture CRSP as an analyst and supervisor in the International Program Office.

Elana Peach-Fine, Graduate Assistant (former)

Elana Peach-Fine currently works as a project analyst for the UC Davis College of Agricultural and Environmental Sciences, International Programs Office.

Students

Kelsey Barale, Graduate Assistant

Kelsey Barale is pursuing master's degrees in International Agricultural Development and Agricultural and Resource Economics.

Erin McGuire, Graduate Assistant

Erin McGuire is pursuing a master's degree in International Agricultural Development.

Azia Hasan, Undergraduate Assistant

Azia Hasan is pursuing a bachelor's degree in American Studies, with a minor in Social and Ethnic Relations.

Special projects staff

Amrita Mukherjee, Junior Specialist

Amrita Mukherjee is the junior specialist on the Horticulture CRSP project for sustainable potato storage in Bangladesh, in partnership with the International Potato Center (CIP). She holds a master's degree in biotechnology and most recently worked for the International Rice Research Institute (IRRI).

Alonso Gonzalez, Team Leader

Dr. Alonso Gonzalez was the team leader for the Horticulture Assessment in Central America. Previously he led the tropical fruits program for the International Center for Tropical Agriculture (CIAT) in Colombia.

Tito Zuniga, Horticulture Specialist

Dr. Tito Zúniga was the horticulturist for the Horticulture Assessment in Central America. Previously he led a national horticultural value chain project in Honduras.

Contact Information

The Horticulture CRSP office is located in room 190 of the Environmental Horticulture Building on the University of California, Davis campus. Our mailing address is:

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YouTube: http://www.youtube.com/user/hortcrsp/about
Flickr: http://www.flickr.com/photos/hortcrsp/

Horticulture CRSP International Advisory Board information

The International Advisory Board is the senior advisory council of Horticulture CRSP. The purpose and role of the Horticulture CRSP International Advisory Board are to advise the Management Entity on all major aspects of the program, including setting priorities, evaluating sub-award requests for application, implementing technical and management approaches, allocating budget and ensuring that USAID, Global Horticulture Assessment and Horticulture CRSP objectives are met.

The membership of the International Advisory Board ranges from 8 to 12 and is representative of the major geographical regions, Horticulture CRSP partner universities and other U.S. and international universities, international agriculture research centers, and the private sector. The Horticulture CRSP Management Entity and USAID representatives serve as ex officio members.

2012-13 Members of the International Advisory Board

Deborah Pierson Delmer, Ph.D.

Deborah Delmer is Private Consultant to foundations and government agencies in the areas of plant biotechnology. She is Professor Emeritus in Plant Biology, UC Davis; former Program Director, BREAD program of U.S. National Science Foundation; former Associate Director for Food Security for The Rockefeller Foundation; and former Chair of Plant Biology, UC Davis. A member of the U.S. Academy of Sciences, Dr. Delmer has been the recipient of the Anselme Payen Award from the American Chemical Society in recognition of excellence in the science and chemical technology of cellulose. She is a member of National Research Council Study on Emerging Technologies in Agriculture and serves on Board of Trustees for PIPRA (Public Intellectual Property Resource for Agriculture) Foundation, the Advisory Board for the US AID Agricultural Biotechnology Support II project, Advisory Board for the Great Lakes Bioenergy Research Center, and on the Science Advisory Board for PepsiCo, Inc. Dr. Delmer rotated off of the board in May 2013.

Adel A. Kader, Ph.D.

Adel Kader is Professor Emeritus of Postharvest Physiology in the Department of Plant Sciences, University of California, Davis. Dr. Kader's activities included mentoring graduate students and postdoctoral researches, participation in teaching several courses on postharvest physiology and technology of horticultural crops and extension of information to producers, handlers, and consumers. He published more than 230 technical publications and edited and co-authored a book on Postharvest Technology of Horticultural Crops. He is the Technical Editor of the University of California, Davis Postharvest Internet Site (http://postharvest.ucdavis.edu). He has served as a consultant on strategies for maintaining quality and reducing postharvest losses of horticultural perishables both within the U.S. and in many other countries, including Chile, China, Egypt, Ghana, India, Jordan, Kuwait, Lebanon, Mexico, Thailand, and Philippines. Dr. Kader received awards for outstanding teaching in 1989 and for distinguished graduate mentoring in 2003 from the University of California at Davis and for best research publications in 1978 and 1980 from the American Society for Horticultural Science (ASHS). He was elected a fellow of ASHS in 1986, President-elect in 1995, President in 1996, and Chairman of the Board of Directors in 1997. He was selected as the Outstanding Horticulturist of 1997 by the Horticultural Research Center at Laval University, Quebec, Canada. In October, 2000 Dr. Kader received the “Award of Distinction” from the College of Agricultural and Environmental Sciences and the “Alumni Citation for Excellence” from the Cal Aggie Alumni Association at University of California, Davis. Dr. Kader died in December 2012.

Poonpipope Kasemsap, Ph.D.
Poonpipope Kasemsap is Associate Professor of Crop Eco-Physiology, Chair of the Horticulture Department, and Director of the International Studies Center at Kasetsart University in Bangkok, Thailand. He is the chair of the International Biology Olympiad (2008-12) and has been the National Coordinator of ThaiFlux Network since 2007. His research and teaching focuses on the effects of climate changes and air pollutants on the eco-physiology of horticultural crops and on the physiology of horticultural crop production. Dr. Kasemsap rotated off the board in May 2013.

J.D.H. Keatinge, Ph.D.
Dyno Keatinge is an agronomist and holds a Doctorate in Agriculture from Queen's University, Belfast, Northern Ireland and is Visiting Professor of Tropical Agriculture at The University of Reading, UK. He has global expertise in crop agronomy and he has worked at many of the Consultative Group for International Agricultural Research Centers including ICARDA in Syria, Pakistan and Turkey, IITA in Nigeria and Cameroon and ICRISAT in India and several countries in sub-Saharan Africa. He also was Professor of Agricultural Systems and Management at Reading University in UK for much of the 1990s and claims to have worked professionally in every continent on earth except Antartica! Presently, he is Director General of AVRDC – The World Vegetable Research and Development Center based in Taiwan and Chairman of the Global Horticultural Initiative.

Josette Lewis, Ph.D.
Josette Lewis is associate director of the UC Davis World Food Center. She previously worked with Arcadia Biosciences to expand the company's licensing and partnerships, particularly in developing countries. Prior to joining Arcadia, Dr. Lewis spent sixteen years with the U.S. Agency for International Development. Most recently, she served as Director of the Office of Agriculture, where she played a leadership role in the development of the Administration's global initiative on food security; development of a new strategy for agricultural research, and initiated numerous new partnerships with universities, agricultural companies, and non-governmental organizations in the U.S. and developing countries.

Norman E. Looney, Ph.D.
Trained first as an agricultural sciences educator and then as a plant physiologist and pomologist (fruit crops horticulture), Dr. Looney achieved early recognition for his pioneering research on the biochemistry and physiology of fruit ripening. Over a 35 year career as a scientist and science manager with Canada's Department of Agriculture he published more than 70 scientific papers, numerous book chapters and learned reviews, and edited two pomology reference books. Very active in several professional societies, Looney was recognized as a Fellow of the American Society for Horticultural Science (1985) and by the Canadian Society for Horticultural Science as a Life Member (2002). In 2006 he became a Fellow of the International Society for Horticultural Science (www.ishs.org). Dr. Looney rotated off the board in May 2013.

Julio López Montes
Julio López is a plant protection specialist and leads classes in integrated pest management and entomology as a professor at the University of Zamorano in Honduras. He is also the director of the Horticulture CRSP Regional Center of Innovation at Zamorano. Professor López has mentored students and participated in several courses on IPM in vegetables, fruits and grains

crops at Zamorano, Nicaraguan and Honduras agricultural universities. He also does extension of information in IPM, Farmer Field School methodology and alternative technologies for pest control for producers, handlers and consumers. He had been involved in several scientific publications in IPM, vegetable crop production, and pest management for farmers. He is also a member of the IPM Network for Central America, the Pest Plant Protection Network of Nicaragua and member of the National IPM Committee of Nicaragua.

Bob Nanes
Bob Nanes is the Vice President of Technology and Innovation for International Development Enterprises (iDE), based at the organization's international headquarters in Denver, Colo. As such, he is in charge of the Technology and Innovation Group, responsible for product development, international procurement, program development, and fostering innovation. He has worked with iDE in various capacities beginning in 1986, including leadership positions with the organization in Ghana, Nepal and Bangladesh. He holds a bachelor's degree in agricultural engineering from Cornell University.

Umezuruike Linus Opara, Ph.D., CEng
Linus Opara is a chartered engineer (UK) and holds degrees in agricultural engineering from the University of Nigeria, Nsukka (BEng Hons cum laude and MEng) and PhD in Agricultural Engineering from Massey University, New Zealand. Prof. Opara is currently a Research Professor and holds the DST/NRF South African Research Chair in Postharvest Technology at Stellenbosch University, South Africa (www.sun.ac.za/postharvest). His activities include mentoring and guiding postgraduate students and fellows, and promoting "PRADA" – a network for Postharvest Research and Development in Africa. He is a member of the Programme Management Unit of the Postharvest Innovation Fund, a joint public-private sector R&D programme for the South African fruit industry.

Robert Paull, Ph.D.
Robert Paull has been a Professor and Researcher in Plant Biology since 1985 at the University of Hawaiʻi at Mānoa. Prior to receiving a PhD in plant physiology at UC Berkeley, Paull was a field agronomist in Australia doing cotton production research. He has served as a consultant to commercial companies, as well as national and international horticulture programs. His international experience includes Bulgaria, Cambodia, China, Colombia, Costa Rica, East Timor, Jamaica, Laos, Malaysia, Philippines, Taiwan, Thailand, Trinidad, Vietnam and West Bank. Paull's area of research is in postharvest handling and storage of tropical fruits, vegetables and ornamentals, especially the impact the of preharvest and postharvest factors on commodity quality. Current research involves changes in the gene expression of plant growth regulators and cell wall enzymes during abscission and fruit ripening. He has co-authored four books and co-edited an additional five, including the Encyclopedia of Fruits and Nuts and numerous peer-reviewed journal articles, conference papers and extension publications. Paull serves as an associated editor on two journals.

Howard Yana Shapiro, Ph.D.
Dr. Shapiro is Corporate Staff Officer of Plant Science and External Affairs at Mars, Inc. and an Adjunct Professor in the Department of Plant Sciences at University of California, Davis. Involved with sustainable agricultural and agroforestry systems, plant breeding, molecular biology and food production systems for over 40 years, he is a founder of Seeds of Change. At Mars, Inc. he is responsible for plant science globally, investigation of potential new plant-base

solutions, and review and oversight of existing and future plant-based research. A former Fulbright Scholar, Ford Foundation Fellow, National Endowment of the Humanities Award winner, Lifetime Achievement Award from the Organic Trade Association, and college professor, Howard is Chair of the External Advisory Board of the Agriculture Sustainability Institute at UC Davis and an award winning author of four books.

Idah Sithole-Niang, Ph.D.
Idah Sithole-Niang is a professor in the University of Zimbabwe's Department of Biochemistry and a board member with the African Agricultural Technology Foundation (AATF). She holds a doctoral degree in biochemistry from Michigan State University. Her primary research specialty is in genetic improvement of cowpea, and is particularly interested in working to improve livelihoods of smallholder farmers in developing countries.

Sally Smith, Ph.D.
Professor Sally Smith is an Emeritus and Adjunct professor in the School of Agriculture, Food and Wine at the University of Adelaide, South Australia where she continues to carry out research on the roles of mycorrhizal symbioses in plant nutrition and growth, particularly in relation to phosphorus uptake in crop plants. She was educated in the UK and holds a PhD from Cambridge University UK and a DSC from the University of Adelaide. She is a fellow of the Australian Academy of Science and the recipient of both the Prescott and Taylor medals of the Australian Soil Science Society. She is a former Board Member and Vice Chair of the Board of the AVRDC-The World Vegetable Center and a keen home vegetable grower.

Lusike A. Wasilwa, Ph.D.
Lusike Wasilwa holds a Ph.D. in Plant Science from the University of Arkansas, Fayetteville, US and a post doctorate from Rutgers University, New Jersey. She has research experience of over 20 years and has authored or co authored several publications, scientific articles and technical papers in a wide spectrum of subject matter with emphasis on molecular plant pathology. Lusike has been working for Kenya Agriculture Research Institute at the headquarters as the Assistant Director in charge of Horticulture and Industrial Crops Division. Lusike is involved in providing leadership to several KARI projects and activities including building, developing and promoting of integrated horticulture and industrial crops product value chains for increased productivity, commercialisation and competitiveness of the crop sub-sector. Dr. Wasilwa rotated off the board in May 2013.

L. George Wilson, Ph.D.
George Wilson has been Professor of Horticultural Science at North Carolina State University since 1975. His research, teaching and extension focuses on postharvest physiology/technology. He was the Senior Advisor for university relations and agriculture research, training and outreach, and Chief of Party of Peru Mission for USAID. His other international in-country positions include Honduras where he was Research Physiologist for nine years for the Division of Tropical Research of United Fruit Company (Chiquita International), Bulgaria and more than 50 countries. He is Past-President and Fellow of American Society for Horticultural Science. George is active in International Society for Horticultural Science and numerous other scientific, technical and honorary societies and represents NC State University as a Horticulture CRSP Partner and served as a member of the Horticulture CRSP Program Council. Dr. Wilson rotated off the board in May 2013.

Detlef Virchow, Ph. D.
Detlef Virchow is the executive secretary of the Global Horticulture Initiative (GlobalHort) and also serves as project coordinator for the research program “Improving food security in Africa through increased system productivity of biomass-based value webs (BiomassWeb)” at the Center for Development Research ZEF-Bonn from the University of Bonn in Germany. He holds a doctoral degree in agricultural economics from the Christian-Albrechts University of Kiel in Germany. Virchow has formerly worked as the executive manager of the Food Security Center at the University of Hohenheim in Germany and director for the AVRDC Regional Center for Africa in Tanzania. His interdisciplinary research has included a variety of food security-related topics, including nutrition-sensitive agriculture, African indigenous vegetables and crop diversity.

List of countries where Horticulture CRSP works

In 2012-13, Horticulture CRSP supported projects in the following countries.

Bangladesh	Kenya
Benin	Nepal
Cambodia	Nicaragua
Democratic Republic of the Congo	Rwanda
El Salvador	Senegal
Ethiopia	Tanzania
Ghana	Uganda
Guatemala	Vietnam
Honduras	Zambia

Prior to 2012, Horticulture CRSP completed projects in the following countries.

Bangladesh	Mexico
Bolivia	Nepal
Cambodia	Nicaragua
Chile	Nigeria
Costa Rica	Panama
Dominican Republic	Peru
Ecuador	Sir Lanka
El Salvador	South Africa
Ghana	Sri Lanka
Guatemala	Tajikistan
Haiti	Tanzania
Honduras	Thailand
India	Uganda
Kenya	Vietnam
Laos	Zambia
Malawi	Zimbabwe

List of Program Partners

U.S. universities

Auburn University
Bridgewater State University
Colorado State University
Cornell University
Michigan State University
North Carolina State University
North Carolina Agricultural and Technical State University
Purdue University
Rutgers, The State University of New Jersey
Tennessee State University
Texas A&M University
The Ohio State University
The Pennsylvania State University
Tuskegee University
University of California, Davis
University of Florida
University of Georgia
University of Hawai'i at Mānoa
University of Wisconsin, Madison

International partners

Bangladesh
- Bangladesh Agriculture Research Institute

Benin
- Abomey Calavi University
- Association des Personnes Rénovatrices des Technologies Traditionnelles
- INRAB
- International Institute of Tropical Agriculture

Bolivia
- Universidad Mayor de San Simón

Cambodia
- Royal University of Agriculture

Chile
- City Council Chillan
- University of Concepcion

Costa Rica
- Universidad de Costa Rica

Democratic Republic of the Congo
- Scheut Tshilomba

Dominican Republic
- Instituto Dominicano de Investigaciones Agropecuarias y Forestales

Ecuador
- Universidad Tecnológica América

El Salvador
- CARE

France
- CIRAD

Gabon
- Institut Gabonais d'Appui au Developpement

Ghana
- Agribusiness in Sustainable Natural African Plant Products
- Council for Scientific and Industrial Research
- Crops Research Institute
- Food Research Institute
- Ghana PolyTechnic Institutes
- Kwame Nkrumah University of Science and Technology
- Selasie Farms and Groceries
- University of Cape Coast
- University of Ghana

Guatemala
- Universidad de San Marcos

Haiti
- Project Haiti WINNER

Honduras
- Corporación Dinant
- Fundación Hondureña de Investigación Agricola (FHIA)
- Zamorano University

India
- Acharya N G Ranga Agricultural University
- Amity International Centre for Postharvest Technology and Cold Chain management
- International Horticulture Innovation and Training Center
- Punjab Agricultural University
- Sathguru Management Consultants, Pvt. Ltd.
- TATA Consultancy Services

Kenya
- Agro Farm Services
- Egerton University
- icipe
- Kangai Tisa Horticultural Farmers Group
- Kenya Agricultural Research Institute
- Moi University
- South Eastern University College

Malawi
- World Relief

Nepal
- Nepal Agricultural Research Council

Nicaragua
- Centro de Investigación Agropecuaria San Antonio
- Universidad Nacional Agraria

Nigeria
- Ahmadu Bello University

Peru
- Universidad de La Molina

Rwanda
- Institut des Sciences Agronomiques du Rwanda
- Kigali Independent University
- Kigali Institute of Science and Technology
- Umatara PolyTechnic

South Africa
- Agribusiness in Sustainable Natural African Plant Products
- Sandra Kruger and Associates
- Stellenbosch University
- University of the Western Cape

Sri Lanka
- Industrial Technology Institute
- Link Natural Products Pvt. Ltd.

Taiwan
- AVRDC, The World Vegetable Center

Tanzania
- AtoZ Textile Mills International
- AVRDC, The World Vegetable Center
- Ministry of Agriculture, Food Security and Cooperatives

Thailand
- Asian Institute of Technology
- ECHO Asia Regional Office
- Kasetsart University
- Maejo University
- Rhino Research

The Netherlands
- Plant Research International

Uganda
- Agribusiness Initiative Trust
- Makerere University
- Mukono District Council
- Mukono Zonal Agricultural Research and Development Institute
- Our Lady Queen of Apostles Nkokonjeru Parish
- Reach Your Destiny Consult, Ltd.
- Rural Agency for Sustainable Development
- Uganda Christian University

United States
- Bent Creek Institute, The North Carolina Arboretum
- NovaFlora, Inc.
- Store It Cold, LLC
- World Food Logistics Organization

Uruguay
- Universidad de la República

Vietnam
- Hanoi University for Agriculture
- Nong Lam University

Zambia
- Agribusiness in Sustainable Natural African Plant Products

Zimbabwe

International Relief and Development

Program Activities, Highlights, and Key Accomplishments

In its fourth year, the Horticulture CRSP continues to advance horticultural science in developing countries by increasing capacity and information access while solving problems along horticultural value chains, with emphases on gender empowerment, technological innovation, income generation and nutrient-rich crops. The Horticulture CRSP funded 17 active research projects in 20 countries during FY13, across a variety of fruit and vegetable crops and at various stages in the value chain.

Our projects trained 13,577 farmers. Nearly 5,000 farmers adapted new technologies. Sixty percent of trainees were women. Our projects have benefited nearly 7500 households, one-fifth of which are vulnerable. We have worked with 1200 organizations and half of those have applied our technologies.

In FY13, the Horticulture CRSP successfully launched its third Regional Centers, in Kenya, and saw the pre-existing two Regional Centers ramp up activities in training and coordinating meetings.

The Horticulture CRSP secured two associate awards; one to conduct an assessment of horticulture constraints in Central America and another to collaborate with the International Potato Center (CIP) in Bangladesh building and testing low-cost smallscale cooling that functions both on and off the grid. We also received money from USDA-FAS to develop a postharvest short course for Central America.

Project highlights include:

- In Benin, 75% of farmers participating in the project adopted pest-exclusion nets for nursery production. Adoption of nets has been shown to reduce pesticide applications.
- In Zambia, a focus on postharvest and the cold chain has improved production for 231 farmers who have produced 1,158 tons of produce for income of $2,034,047.
- The Horticulture Innovation Lab completed training 36 postharvest trainers and opened a postharvest training and services center. The trainers have in turn trained more than 16,000 smallholder farmers (this includes FY12 data).
- Women's cooperatives in Guatemala and El Salvador are now producing and selling improved tomato and pepper seedlings. By adding grafting to their skills and business plans, the women have now doubled their income per seedling.

Research program overview and structure

Horticulture is the production, postharvest handling and marketing of fruits, vegetables, herbs, spices and ornamental plants. 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 human health in the developing world, while providing prospects for income diversification and consequent economic and social advancement of the rural poor. In addition, women are in many cases the main producers and marketers of horticulture crops, so increased horticultural production often leads to an improved income stream for women and their children.

Horticultural crops such as green leafy vegetables, tree nuts, and orange fleshed sweet potatoes contain key vitamins and micronutrients. Increased horticultural production can help reduce the nutrient deficiencies that lead to decreased cognitive development in young children and as a result reduce adult economic and social potential. Typically, horticultural crops are both highly nutritious and economically valuable. Horticultural research is crucial to enable small-scale producers to overcome agronomic and market barriers and realize the benefits offered by horticultural development.

The Horticulture CRSP is committed to transparency, and particularly to open competition for awards. The purpose of each call for proposals is different, but each call has been open to all persons with PI status at public universities with the exception of continuation and focus projects which were targeted to investigators who had already received Horticulture CRSP funding on previous proposals. A concerted effort is made to target Historically Black Colleges and Universities (HBCU) and Minority Serving Institutions (MSI) when RFAs are released.

The Horticulture CRSP has funded seven types of subawards to date, each with a different size and scope of activities. The seven subaward types are: Immediate Impact Projects (IIPs), Exploratory Projects (EPs), Pilot Projects (PPs), Comprehensive Projects (CPs), Continuation and Focus Projects (FPs), and Trellis Fund Projects. There is a specific rationale for each type of project.

Immediate Impact Proposals (IIPs): Leveraging shovel ready horticultural proposals to the USDA and their respective PI's, the Horticulture CRSP seized the opportunity to hit the ground running with their first set of 15 projects. These projects were funded up to $150,000 for one year. This relatively modest sum was committed to the projects in order to use existing connections or research to make an immediate impact in a short period of time. The wide net of 15 projects also allowed the Horticulture CRSP to gain valuable experience about working with the projects and gain more perspective about our relative strengths.

Exploratory Projects (EPs) were the next set of projects and were funded at $75,000 for one year. Through our first set of projects the Horticulture CRSP recognized that many researchers in the U.S. and in developing countries have the interest and capability to conduct appropriate research and training programs, but have not developed the teams or the background information/proof of concept that would ensure success in an application for a more long-term, involved project. The intent of the Horticulture CRSP Exploratory Projects was to provide funding that would encourage formation of such teams and the acquisition of background or preliminary information that could provide the basis for a more comprehensive long-term project.

Pilot Projects (PPs) are a longer-term source of funding for awards of up to 3 years duration at up to $500,000. These projects were more comprehensive in nature and were asked to conduct research that addresses one or more of the three themes of the Horticulture CRSP: building local scientific and technical capacity, applying research findings and technical knowledge to increase small producers' participation in markets, and facilitating the development of policies that improve local horticultural trade and export capacity. Our prior experience with IIPs and EPs allowed us to successfully evaluate valuable projects for committing this larger investment. PPs needed to demonstrate prior or initial problem analysis and include benchmarks for evaluation of performance and some were developed out of the original IIPs. As these proposals were larger in scale and scope funded projects were crosscutting and interdisciplinary. Moreover, all proposals were required to include a training and education component, and to demonstrate how successful completion would not only facilitate the participation of the rural community in the horticulture value chain, but would also build research and/or training capacity in the target country or region.

The Comprehensive Projects (CPs) were a response to direct feedback from the International Advisory Board and from USAID that encouraged us to commit our remaining funding to more long-term comprehensive projects. These projects were expected to consider the entire system within the chosen topic area, but focus the greatest attention on bottlenecks within that system. The four topic areas were Seed Systems, Postharvest, Orange fleshed Sweet Potato and African Indigenous Vegetables. From our past experiences we learned the value of collaboration and encouraged PIs that had previously worked with Horticulture CRSP to consider collaborations with other Horticulture CRSP PIs and collaborators that may have needed expertise for their proposal, as well as PIs and collaborators not currently associated with Horticulture CRSP.

Continuation Projects and Focus Projects (FPs) were targeted proposals that were borne from successes in past projects or identified bottlenecks in current projects. As these projects target particular issues or audiences they were not open to competition. However, it should be noted that not every continuation or focus project solicited was funded. These projects are funded at different levels and for different periods of time depending on the identified needs.

The Trellis Fund subawards program allows the Horticulture CRSP to directly develop the capacity of US graduate students and small in-country organizations by connecting them with one another to work collaboratively on a small project identified by the in-country organization. These very small competitive grants ($2,000 to the organization for a period of 6 months plus US graduate student travel costs) enable developing-world organizations (DWO) to empower smallholder farmers with new information as well as build longstanding relationships between DWOs and U.S. researchers. The Trellis Fund was created with the belief that small organizations can do significant work, especially where they have strong ties to the community, but they are often excluded from grant opportunities because of economies of scale. We also believe that U.S. graduate students are motivated and can leverage their resources to assist organizations in their activities and will be encouraged to carry international work into their research and professional futures through this project.

Guiding Policies

The main policies that guide our decisions are the University of California, Davis policies, USAID policies, and especially the USAID Feed the Future initiative.

The Horticulture CRSP adheres to the University of California, Davis mission of national and global engagement and public. Our work draws on the combination of horticultural and allied expertise and international connections of the faculty in the UC Davis College of Agricultural and Environmental Sciences (CA&ES).

Horticulture CRSP is also guided by the overarching goals of USAID and the priorities identified in the 2005 USAID Global Horticulture Assessment. The most important initiative that guides our activities is the USAID Feed the Future plan. In May 2010, the USAID announced a $3.5 billion, three-year Presidential Initiative called Feed the Future. By targeting regions within 20 focus countries and focusing on women's empowerment, diet quality and diversification, postharvest and infrastructure, high quality inputs and financial services, Feed the Future program aims to increase agricultural production and incomes of the rural poor.

Horticulture CRSP contributes to the Feed the Future Initiative in several ways. As soon as the initiative was announced, Horticulture CRSP projects were refocused on the Feed the Future priority countries, especially those that had identified horticultural crops as priority commodities. Horticulture CRSP has continued to increase the number of partners in these countries and devoted larger amounts of money to projects in those countries.

In addition, Horticulture CRSP's priorities naturally fall within the Feed the Future Initiative:

- Improving horticultural crop production empowers women by giving them access to increased income.
- Enhancing household horticultural production improves local diets by increasing access to horticultural foods that are rich in micronutrients.
- Decreasing food losses after harvest creates stronger value chains and gives smallholders greater access to markets.
- Building capacity of local agribusinesses, processors, extension educators, and agricultural researchers ensures that horticultural improvements are long-lasting and sustainable.

The work of Horticulture CRSP impacts women and children in 16 of the 19 Feed the Future priority countries. Our work in these countries ranges from enhancing seed systems to developing safe harvest and storage strategies that work in smallholder production situations. By working along the entire horticultural value chain and building capacity through trainings and improved technologies, Horticulture CRSP contributes to the efforts of the United States Government.

Themes and Collaborations

The Horticulture CRSP has 4 major themes that are addressed by our projects in different ways: Innovative Technology, Gender Equity, Access to Information, and Building Local Human and Institutional Capacity.

Information accessibility

The Global Horticulture Assessment (2005) notes the desperate need in rural communities for information – on marketable crops and varieties, on production techniques, postharvest handling, and market requirements and access. Information access is addressed through our individual projects in different ways including: websites, permanent demonstration plots, and written materials. The Horticulture CRSP Management entity also comprises an information management team. Our information strategy focuses on:

1. Understanding existing dissemination practices and help partners develop enhanced dissemination strategies (including use of emerging information communication technologies)
2. Improving access to information on horticultural technologies and how they can best be applied

We address these specific objectives by capturing information from projects, developing and distributing technical information through our Centers of Innovation, capturing information and feedback during our Horticulture CRSP meeting and through a series of information access activities. Through the information access activities the information management team is working to answer the following questions through workshops, and project, PI and collaborator interviews and surveys:

1. Needs - How are audiences and their needs identified?
2. Source - Where do people (organizations) get their (credible) information?
3. Delivery
   a. What is their approach to information dissemination?
   b. What are the greatest challenges and opportunities (including new tools)
4. Feedback - how do they collect feedback

Innovative technologies

Horticulture CRSP encourages projects that explore 'disruptive' or 'leapfrog' technologies providing advanced tools, in an appropriate form, to stimulate and facilitate horticultural development in the developing world. Such technologies have the potential to directly benefit farmers by decreasing costs and increasing efficiency. Technologies addressed through Horticulture CRSP projects so far include solar drying, pest-exclusion nets and drip irrigation, improved cultivars, electronic controllers that use window air conditioners to provide low-cost coolrooms, and Zeolite beads for rapid drying of seeds and other horticultural products. All of these technologies were tested and developed through a collaborative effort between U.S. researchers and their partners at National Research Institutes in Feed the Future countries. Future emphases of Horticulture CRSP technology development will include postharvest, improving nutritional value of African Indigenous vegetables and innovative energy solutions in horticulture, such as off-grid evaporative cooling technologies and the use of photovoltaics in pumping, desalination, and other energy-intensive horticultural operations.

Gender equity

In the developing world, women can provide as much as 90% of the labor for the production of horticultural crops. Although they represent a reservoir of production and marketing knowledge of what are often termed 'women's crops' they usually are compensated with lower wages and less permanent positions than those available to men. Lacking knowledge of how finance works and where to get it, as well as collateral to insure it, women have unequal access to technology and production inputs and therefore reduced opportunities for economic advancement. As such, Horticulture CRSP projects focus on expanding opportunities and providing technologies to women. By training nearly 50% women, our projects ensure that women have access to novel production practices, advanced market opportunities, and the food safety or nutritional information to keep their families healthy.

Capacity Building

Building local scientific and technical capacity is a theme and a top priority for Horticulture CRSP. In addition to training farmers, Horticulture CRSP engages new institutional partners throughout the world each year. Horticulture CRSP funding is provided directly to most of these institutions – enabling them to directly serve those working in the horticulture industry while simultaneously conducting the research that is crucial to Horticulture CRSP priorities. Horticulture CRSP projects also support over dozens of graduate students. These students live and conduct research in the United States as well as most of our Feed the Future project countries. While every Horticulture CRSP project includes a capacity building component, Horticulture CRSP is specifically focused on building capacity in the areas of postharvest and food safety. A variety of projects focus on this topic in particular.

Horticulture CRSP Research Project Briefs

The following section includes one-page briefs of current Horticulture CRSP projects. For more detailed technical reports, please see Appendix I. The detailed technical reports include research data and are distilled from annual project reports required of each project. For more detailed technical reports, please contact Horticulture CRSP. For projects that were previously funded by Horticulture CRSP prior to October 2012, please visit http://horticulture.ucdavis.edu/main/projects.htm.

Briefs are provided for the following projects:

Theme: Seed systems and germplasm

- Project 1: Seed Systems – Improving Seed Quality for Smallholders in Nepal, Bangladesh, Kenya, Tanzania, Uganda, and Rwanda led by Kent Bradford of University of California, Davis
- Project 2: Semillas de Esperanza: Vegetable Seeds for Sustainable Agriculture in El Salvador, Guatemala, Honduras, and Nicaragua led by James Nienhuis of University of Wisconsin-Madison

Theme: Sustainable production of horticultural crops

- Project 1: Developing Low-Cost Pest Exclusion and Microclimate Modification Technologies for Small-Scale Vegetable Growers in Benin and Kenya led by Mathieu Ngouajio and Vance Baird of Michigan State University
- Project 2: Empowering women vegetable growers with drip irrigation in Cambodia led by Manuel Reyes of North Carolina A & T State University

Theme: Postharvest

- Project 1: Extension of Appropriate Postharvest Technology in Sub-Saharan Africa: A Postharvest Training and Services Center in Benin, Ethiopia, Ghana, Kenya, Rwanda, Tanzania, and Uganda led by Diane Barrett of University of California, Davis
- Project 2: Sustainable Development of Horticultural Crops in Zambia by Introducing Postharvest Technologies and Practices for Food Security, Income Generation and in Support of the Tourism Industry in Zambia led by Jim Simon of Rutgers University
- Project 3: Developing Training Materials to Improve Postharvest Practices in Guatemala and Honduras led by Jeffrey Brecht of University of Florida

Theme: Food Safety

- Project 1: Delivering Vegetable Safety Education through Established Social Networks in Guatemala, Honduras, and Nicaragua led by Jeffrey LeJeune of The Ohio State University

Theme: Nutrition

- Project 1: Sustainable Technology for Orange and Purple Sweet potato (STOPS)in Ghana led by Eunice Bonsi of Tuskegee University

Theme: Marketing

- Project 1: Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers in Kenya, Tanzania, and Zambia led by Stephen Weller of Purdue University

- Project 2: Increasing Food Safety and Creating a Niche in the Market for Smallholders by Educating Them in Production, Postharvest, Food Safety, and Marketing and Branding their Produce According to Specific Food Safety Standards in Cambodia and Vietnam led by Cary Trexler at University of California, Davis

Theme: Enabling environment

- Project 1: Increasing the Capacity of Smallholder Farmers to Produce and Market Vegetable Crops in the Democratic Republic of Congo and Uganda led by Kate Scow of University of California, Davis
- Project 2: Innovative Energy Solutions in Horticulture led by James Thompson of University of California, Davis
- Project 3: UC Davis D-Lab & Horticulture CRSP Innovation Centers: Providing support & capacity building to bring appropriate technologies to market in Honduras and Thailand led by Kurt Kornbluth of University of California, Davis

Project Name: Improving Seed Quality for Smallholders in Bangladesh, Kenya, Nepal, Rwanda, Tanzania, and Uganda

Project Description

High quality seeds of improved varieties are essential to enhance the production of annual horticultural crops. In tropical climates, high temperatures and humidities combine to cause rapid deterioration of seeds in open storage, resulting in loss of value, poor stand establishment, lower productivity and disincentive to invest in improved seeds. Most horticultural seeds in the targeted locations are locally produced or self-saved and are stored without facilities for drying them to moisture contents that would greatly extend their storage lives. We propose to demonstrate a simple, inexpensive and widely adaptable method for drying horticultural seeds and maintaining high seed quality during storage. A novel zeolite desiccant, combined with inexpensive hermetic containers, can both dry horticultural seeds and maintain them in a dry state during storage, greatly increasing their storage lifetime. As women perform most of the seed production, harvesting and storage operations for horticultural seeds in these regions, adoption of this system would have direct benefits by enhancing the value of their labor. This simple seed drying and storage system would enable the development and distribution of more productive varieties, marketing of higher quality products and increases in women's and families' incomes.

Collaborators:

US

- Kent J. Bradford, Principal Investigator, University of California, Davis

Nepal

- Luke Colavito, International Development Enterprises (iDE)
- Jwala Bajracharya, Nepal Agricultural Research Council (NARC)
- Indra Raj Pandey, Center for Agricultural Policy Research, Extension and Development (CEAPRED)

Kenya

- Roger Day, CABI Africa (Centre for Agricultural Bioscience International)

India

- Keshavulu Kunusoth, Acharya N G Ranga Agricultural University

Thailand

- Johan Van Asbrouck, Rhino Research
- Ganesh Shivakoti, Asian Institute of Technology (AIT)

Key Accomplishments:

- The project's key accomplishment this year was formulating and disseminating the concept of the "dry chain" to encompass the entire process of drying, packaging and storing dry commodities. This concept is a success because it is conceptually easy for stakeholders to understand and remember. It will be crucial that the project develop the dry chain in the coming months.
- Another success is the project's shift in emphasis to encourage capturing dry environmental conditions with hermetic packaging when possible and using drying beads to further dry seeds and commodities when required.

Capacity Building:

The project conducted a number of capacity building trainings and workshops for farmers and agrovets. Overall, the program has provided short-term training to 2081 (997 male, 1084 female) farmers, 1776 producers, and 227 people in government. Of the farmers who have received short-term training, 119 have applied new technologies as a result of the trainings. One degree-seeking graduate student and two Ph.D. students are currently affiliated with the program.

The following trainings took place, by country:
US:

- Kent Bradford conducted a workshop with participants from several Central American countries associated with his project to select improved tomato and pepper varieties. Dr. Bradford trained participants (18 total, 6 female) in application of drying beads for storing horticultural seeds and provided with a packet of beads.

India:

- The project conducted a two day for Researchers from State Agri. Universities, ICAR, Seed researchers and MS students. The sessions included training on seed quality components, background of seed drying storage, basic seed storage, the effect of RH/MC content for safe seed storage. The training also covered drying bead technology. On the second day, the project conducted a demonstration of the drying test where the trainees learned how to estimate the bead capacity and conduct reactivation. On the second day (participants collected data from the drying demonstration and estimation of bead capacity.

Tanzania:

- On June 5, 2013, the project provided training on drying bead technology to seed growers at Maweni village by interacting with seed growers on general seed production practices.
- The project organized an educational program on drying bead technology at Arusha, Tanzania on June 3-11, 2013 where CABI, Kenya had ongoing demonstration experiments. The participants tested the equilibrium relative humidity of seeds inside the containers and compared with ambient RH.
- On June 7, 2013, the project organized a training demonstration on drying bead technology for seed industry and scientists of Horticulture Training and Research Institute, Tengeru. All the participants visited ongoing storage experiment at Horticulture Training and Research Institute, Tengeru and had an interaction about the technology.

Kenya:

- A Demonstration/training program on beads took place on May 6-10, 2013, in Nairobi, Kenya.
- A demonstration and training program was organized at the opening ceremony of the Practical Training Center, which is part of Horticulture CRSP Regional Innovation Center at Thika, Kenya.

Bangladesh:

- The project conducted a training for six seed technologists of national seed companies Lalteer, Supreme, Metal, ACI, Getco and Partex.
- There was a training on use of zeolite for postharvest drying of seeds for 28 (23 women, 5 men) corn seed producing farmers in Dhading district in August 2013.

Cambodia:

- A demonstration/training program took place at the Royal University of Agriculture (RUA), Phnom Penh, Cambodia at the 3rd Annual Meeting of Horticulture Action Research & Education Network on July 26-27, 2013.

Nepal:

- There was a large-scale demonstration of onion seed drying at SEAN Seed Company and Kathmandu Agro Concern, Lalitpur.
- The project conducted farmer group trainings on bead technology at Lele, Lalitpur and Kavre from June-August.
- The project provided bead technology training for Business & Professional Women (BPW), women entrepreneur groups of Kathmandu chapter (Kathmandu, Bhaktpur, Lalitpur) at soil science division, NARC, Khumaltar
- Short training on bead technology occurred on June 28, 2013 for Junior Technicians at District Agri Development Office from eastern districts at NWRP, Bhairahawa.
- A two-day demonstration and training program on drying bead technology was organized by Horticulture CRSP/CEAPRED, Kavre, at two new co-operatives namely Panchkanya Seed Producer Cooperative, Sarsyunkharka, and Shuvaprabhat Seed Producer Cooperative, Kanpur, Kot Timal on August 13-14, 2013.
- Zeolite beads technology training was conducted at NWRP, Bhairahwa to 20 (12 male, 8 female) technicians of the District Agricultural Development Office.

Thailand

- An "International Training Course on Modern Technology for Sustainable Agriculture System" was organized at Naresuan University, Thailand.. Rhino Research delivered the training on seed technology including "Drying and Seed Storage" and provided free one-kg bead samples to 17 participants.
- Training was organized for bead distributors from India and Australia during August 19-23, 2013. New employees of Rhino research also attended this training on "Drying Beads" at the new Rhino Research Office in Bangkok. There were 14 trainees (female 5, male 9) including 2 dealers each from India and Australia.

Publications

1. XIII ISST National Seed Seminar 20130001-Bengaluru. Kunusoth, K., Dahal, P., Sultana, R., and Bradford, K.J. 2013. An innovative and low cost technology for seed drying to maintain quality.
2. A website (www.dryingbeads.org) was improved and is being populated with information, instructions, demonstrations and data related to the use of drying beads.
3. A manuscript was submitted to Food Policy on August 17, 2013, describing some of Krishna Timsina's results from economic surveys of seed use and the value of improved storage in Nepal (citation below). However, it was not accepted as the editor noted that "The paper is focused exclusively on Nepal. As such it does not meet our criterion for publication that all papers should make clear links into food policy debates of international interest." The paper was subsequently submitted to the Journal of International Development on September 10, 2013 and is currently under review.
4. Timsina K, Dahal P, Bradford KJ, Kunusoth K, Van Asbrouck J, Pandey IR, Bajracharya J, and Shivakoti G. Introduction of a new seed drying and storage technology for improving the livelihoods of smallholder farmers in Nepal. Journal of International Development: in review.
5. Instructional materials used at trainings and demonstrations in Nepal (A40119).

6. Media reports. The news of the training cum demo on beads at Dhading was published in "Dhading Awaaj-Daily" on September 8, 2013 (http://dhadingnews.com/?p=5597).

Project Name: Producing local, disease-resistant vegetable seed in Guatemala, Honduras, El Salvador, Nicaragua

Project Description

Acute poverty and meager economic opportunities exist in many rural regions of Central America. Vegetable and seed production are technology-driven economic activities that can significantly contribute to economic growth in communities and families and specifically provide new opportunities that contribute to the economic empowerment of women. The factors limiting this horticultural transformation are access to:

i) vegetable cultivars with resistance to endemic diseases,
ii) high quality seed of adapted cultivars,
iii) business know-how and basic management and marketing skills, and
iv) connections to regional supply chains that provide stable, predictable markets–Hortifruti Wal-Mart Centroamérica.

Cultivars developed by the World Vegetable Center (AVRDC) have demonstrated tolerance to diseases endemic to Central America. Quality seed can be produced in the tropics in screen houses. The UW Center for International Business Education and Research (CIBER) is a small business incubator. Hortifruti is the dominant regional purchaser, distributor and marketer of vegetables. The supply chain benefits include:

i) families and women's groups develop technology-based seed and vegetable production businesses within each country.
ii) access to high quality seed of adapted cultivars reduces risk, minimizes losses and increases profitability in sustainable production for growers, cooperatives and women's groups.
iii) increased consumption of vegetables contributes to a healthier, more diverse diet.

Collaborators:

USA:

- Jim Nienhuis and Suzanne Dove, University of Wisconsin- Madison

Taiwan

- Peter Hanson and Paul Gniffke, AVRDC- The World Vegetable Center

El Salvador

- Doris Hernandez and Edgar Ascencio, CARE

Guatemala

- Claudia Eugenia Flores de Leon, CARE

Nicaragua

- Martha Moraga, Maria de los Angeles, Francisco Salmeron and Tomas Laguna, Universidad Nacional Agraria de Nicaragua

Honduras

- Donald Breazeale, Fundacion Hondurena de Investigacion Agricola

Key Accomplishments:

- 18 participants from Honduras, Nicaragua and Costa Rica participated in a drying beads workshop led by Kent Bradford, and women's groups in all three countries adopted the technology. A separate workshop was held in Guatemala, where a women's group also adopted the technology.

- In country partners evaluated 10 tomato lines from AVRDC, and local women's groups selected which of these varieties they wanted to grow.
- Women's groups in El Salvador and Guatemala adopted AVRDC tomato and pepper seeds, and have begun growing seedlings to sell.
- In Guatemala, the Tajomulco women's group produced and sold 1500 tomato seedlings to local growers, and has orders for 3000 more.
- The project is working to build collaborations around grafted seedlings, which have great potential in the region since they can resist soil-borne pathogens.
- Organizational partners in Central America have begun to collaborate as a result of the project.

Capacity Building

21 people (9 women) from 5 countries participated in a short course of seed drying beads held by Dr. Kent Bradford and Dr. Jim Nienhuis at the University of Wisconsin-Madison. The training included a classroom-based workshop on seed drying bead technology, followed by hands-on experiments with the beads and visits to local farms and markets. The goal of the workshop was to build knowledge and confidence around the postharvest physiology of seeds and seed storage.

Three Guatemalans (2 female) were trained on seed drying beads in Guatemala, since they had been unable to attend the Wisconsin training due to visa issues.

In addition, 4 students (2 female) worked on this project. One master's student at UW Madison was fully funded by the project, and three undergraduates from Guatemala and Costa Rica participated in but were not funded by the project.

Publications

Two student theses at the Univ. de San Carlos, Guatemala were completed, one on tomatoes and the other on chili peppers. Both dealt with evaluation of the materials provided by the World Vegetable Center, Taiwan. I do not have the thesis, but the names and titles will be sent to me by Wilder Martinez, Tajomulco, Guatemala. Both Theses have been published.

Low cost pest exclusion and microclimate modification technologies for small-scale vegetable growers in East and West Africa

Project Description:

Rapid urbanization in Sub-Saharan Africa (SSA) has resulted in an increase in demand for food. Almost 33% of the SSA population, close to 200 million people, is undernourished (FAO, 2006). Fruit and vegetable consumption in SSA remains 22-82% below the intake value threshold of 400 g/day recommended by the World Health Organization and Food and Agricultural Organization. This severe malnutrition leads to many chronic diseases among the populations. Vegetable growers, mainly small holders are poor and have no access to inputs for improved germplasm, pest and disease control tools, and improved crop production techniques. Vegetable farms are routinely devastated by pests and extended drought conditions. We propose to harness alternative pest management techniques, micro-climate modifications, and growers' education and training to improve small-scale vegetable production in East and West Africa. A participatory approach will be used to demonstrate efficacy of 1) Eco-Friendly Nets (EFN); insect barrier nettings (either treated or not with insecticides) at protecting vegetables against pests and associated viral diseases 2) floating row covers at improving crop micro-climate and enhancing yield and produce quality, 3) Assess and address farmer's perception of EFN in order to increase the adoption and use of the technology.

Collaborators:

Benin

- Françoise Komlan, INRAB, Benin
- Anselme Adégbidi, Abomey Calavi University, Benin
- Damien Ahouangassi, Association des Personnes Rénovatrices des Technologies Traditionnelles' (APRETECTRA), Benin
- Serge Simon, INRAB/CIRAD, Benin

France

- Thibaud Martin, CIRAD, France
- Laurent Parrot, CIRAD, France

Kenya

- Lusike A. Wasilwa, KARI, Kenya
- Mwanarusi Saidi, Egerton University, Kenya

Tanzania

- Pierre Guillet, AtoZ Textile Mills International, Tanzania

Key Accomplishments:

In Kenya:

- Tested effects of EFN mesh size, type (treated or untreated) and color on different crops. Established the effectiveness of nets in improving microclimate conditions and reducing pest populations in a number of crops, including cabbage, tomato, French bean, onion, carrots, and kale.
- Determined that when managing red spider mites, *T. evansi,* in the leafy vegetable Solanum scabrum, Acarcide-treated nets combined with the predatory mite *Phytoseiulus longipes* are more effective than either management technique on its own.
- Net technology adopted by several small scale cabbage growers.
- Better cabbage, spinach beet and tomato yields reported in farmer fields.

- Socioeconomic studies at KARI conducted on socioeconomic and cultural impact of the technology at farm level

In Benin:

- 7 dry season and 2 rainy season trials implemented
- Completed three trials on EFN technology in cabbage and tomato plants. Trials on tomato plants showed that tomato has better growth and fewer pest populations when grown under EFN than without.
- Discovered key factors in farmers' adoption of EFN technology. These include considerations of cost, labor, social influence, and profitability of EFN use.
- 185 farmers trained on the use of insect nets, and four farmers have received assistance from the project.

Capacity Building

Kenya

At Egerton University, one MSc student graduated in July 2013, one MSc student successfully defended their thesis and is scheduled to graduate, one PhD student collected preliminary data, and two new students who joined the project successfully defended their proposals and have embarked on their field work. 400 BSc students, 370 Diploma students (500 male & 270 female) and 417 visiting high school students (226 male & 191 female) received training in EFN technology at Egerton University. In September, Egerton and the Ministry of Agriculture also organized a field day in Nakuru North District demonstrating EFN technology.

KARI has given both male and female M.S and B.S students the opportunity to conduct research. The students come from various local universities: Kenyatta University (5), Kenya Methodist University (1), University of Eldoret (1), Moi University (1), Kenya University of Technology (1), and the University of Nairobi (2).

In the Njoro area of the Rift Valley, farmer training in EFN use continued. Extension officers introduced EFNs to farmers' fields to enable the farmers to compare effectiveness of the nets on cabbage and tomato pests and microclimate conditions. Fifty four additional farmers were recruited into the project in Njoro.

Benin

One MSc Student graduated with Master 2 Hortimet at Sup'Agro Montpellier (France). 3 BSc students are interns in the project at INRAB

To date, 185 farmers have been trained on the insect net use. This year, six new farmers joined the project. Researchers conducted training sessions on physical control and insect net use for farmer participants. Over 100 vegetable growers participated in this training throughout the Tori-Bossito and Come municipalities. Four farmers' organizations have received assistance from the project.

In addition to training on net technology, the project also provided capacity building activities on the economic aspects of the projects. Six surveyors received training on profitability and economic concepts. Four farmers were trained on cost-benefit data management.

Publications:

Achieng'a FC, M Kasina, J Mbugi, L Wasilwa, M Ngouajio, P Kipyab, and T Martin (2013) Infestation of tomatoes (Solanum lycopersicon L.) by pests when protected with Agronets in Central Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013.

Gateri JW, P Kipyab, L Wasilwa, PA Kamau, M Ngouajio, T Martin and M Kasina (2013) Pest infestation of cabbages under different Agronet deniers and structure height. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 56

Guantai G, M Kasina, J Mbugi, S Mwaniki, L Wasilwa, M Ngouajio, and T Martin (2013) Comparing efficiency of cover duration and mesh size of pest exclusion net covers against cabbage (Brassica oleraceae var. capitata) pests in Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 53

Juma V, M Kasina, L Wasilwa, E Kokwaro, P Kipyab, F Kariuki, M Ngouajio and T Martin (2013) Tomato (Solanum lycopersicum L.) protection with Agronets affects pest population and yields under Kenya growing condition. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 52

Kiptoo J, M Kasina, P Kipyab, L Wasilwa, F Wanjala, M Ngouajio, T Martin (2013) Evidence of cabbage-pest suppression using low-cost exclusion nets at Kabete and Thika, Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013.

Martin T., R. Palix, A. Kamal, E. Delétré, R. Bonafos, S. Simon and M. Ngouajio 2013. A repellent treated netting as a new technology for protecting vegetable crops. Journal of Economic Entomology 106(4): 1699-1706 (2013); DOI: http://dx.doi.org/10.1603/EC13004

Muleke EM, Saidi M, Itulya FM, Martin T and Ngouajio M. 2013. The Assessment of the Use of Eco-friendly Nets to Ensure Sustainable Cabbage Seedling Production in Africa. Agronomy, 3(1): 1-12.

Saidi M, Gogo OE, Itulya FM, Martin T and Ngouajio M (2013) Microclimate modification using eco-friendly nets and floating row covers improves tomato (Lycopersicon esculentum) yield and quality for small holder farmers in East Africa Agricultural Sciences Vol.4, No.11.

Sakwa R; F. Olubayo, L. Wasilwa, M. Ngouajio, P. Kipyab, T. Martin and M. Kasina (2013) Effects of Agronets on French bean (Phaseolus vulgaris l.) pollination in Nairobi Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 59

Simon, S., Assogba Komlan F., Adjaïto, L., Mensah, A., Coffi, H., Ngouajio M. and Martin, T., 2013. Insect nets performance on field cabbage production is affected by mesh size, net removal frequency and induced microclimate. Submitted to International Journal of Agricultural Sustainability

Too A, E Kiprop, M Otipa, L Wasilwa, T Martin, Ngouajio M, and Kasina M (2013) Disease manifestation and management on nursery tomatoes (Solanum esculentum Mill.) protected from insect pests using agronet in Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 63

Vidogbena F. and Simon S., 2013. Physical control of cabbage and tomato pests in South Benin. Ecole-Chercheur Ecohort, Sète, 11-14 of March 2013. In preparation.

Empowering Women Vegetable Growers with Drip Irrigation in Cambodia

Project Description

Horticulture crop production, a women's domain in Southeast Asia, is plagued by yield losses because of drought, and unequal opportunities for women (Chiong-Javier, 2009; Holmes and Slater, 2008; Spieldoch, 2007). Among the main introduced technologies in horticulture, drip irrigation has been shown to replace time consuming tasks of hand irrigation and fertilization, increase yield and quality of horticulture crops, reduce pests, and save water (Palada et al, 2010a, 201b; Ella 2008, Ella et al, 2009, 2010, and 2012; and Reyes, 2009, 2008, and 2007). When targeted at women, drip irrigation has been also found to increase women's productivity and income, enhance their welfare by reducing drudgery, decreasing workload, improving health and saving time for other practical needs, as well as empowering them with a stronger voice in the family and community (Upadhyay, 2003).

The project will target a rural site in Siem Reap, Cambodia. The area is home to several grand temples like Angkor Wat, which is a popular tourist destination. Vegetables can be marketed in restaurants and hotels serving the tourism community where only 30% of vegetables are supplied from Cambodia. Hence, the women of Siem Reap can supply pesticide-free fresh vegetables to the market that is at most 1 hour away.

Collaborators:

USA:

- Manuel Reyes and Don Edralin. North Carolina A&T State University

Cambodia:

- Chansereivisal Duong and Yun Sinang, Agricultural Development Denmark Asia

Key Accomplishments:

- Partners identified 3 women's groups to pilot the irrigation project
- Women's groups were trained in using irrigation with conservation agriculture practices
- 15 drip irrigation systems installed in participating women's households
- Women's groups grew cucumbers (2 groups) and kale (1 group) using drip irrigation
- Women's groups are recording their costs, time spent and income generated so the project can conduct a cost-benefit analysis

Capacity Building:

- The two Cambodian partners who work at ADDA were trained on drip irrigation and conservation agriculture practices.
- Ren Ry, the tuktuk driver, was trained as a field technician for the project.
- Don Edralin, a NCA&T PhD. Student, conducted research in Cambodia over the summer.
- The 15 women's groups who received drip irrigation systems were trained on how to do conservation agriculture with drip irrigation.

Presentations and Publications

Edralin, D.I. and M. Reyes. Conservation Agriculture with Drip Irrigation in Siem Reap, Cambodia. Poster presented at the Water Education Symposium held at Chattanooga, TN, September 24-26, 2013.

Opening a Regional Postharvest Training Center in Rwanda, Ghana, Kenya, Tanzania, Benin, Ethiopia, Uganda

Project Description

Physical losses of horticultural crops postharvest continue to range from 30-80% in Sub-Saharan Africa (SSA), and problems with food quality, safety and nutritional value are well documented. While past projects have identified appropriate postharvest technologies and recommended a variety of training, capacity building and small-scale infrastructure development, no single project has integrated all of this information and offered a locally based solution. This unique pilot project for smallholder farmers in Arusha, Tanzania, combined a wide variety of training programs, adaptive research and demonstrations of postharvest practices and services aimed at reducing losses and increasing shelf life. Via a postharvest shop set up nearby in Njiro, it will provide on-site ready access to the tools and supplies people need in order to reduce postharvest losses and improve market access and incomes for the smallholder farmers, women farmers and village level processors in the northern zone of Tanzania who are affiliated with established cooperatives and farmers associations near Arusha.

The project site in Tanzania will serve as a model for postharvest development in six additional SSA countries, whose representatives participated via collaboration with African partners. By the close of project, 36 postharvest specialists from the 7 SSA countries involved will be well qualified to implement enhanced postharvest handling techniques. They have already extended postharvest information and training on improved handling practices to approximately 16,000 smallholder farmers and village level food processors in their home countries. Many of those trained have gone on to share their training with others (a multiplier effect reaching about 15,000 additional trainees), and the initial monitoring and evaluation completed during the project showed that those who receive training are using their new knowledge and skills. This has resulted in reports of increased consumption of higher quality produce and better returns on investment for smallholder producers and rural women.

Collaborators

USA
Principal Investigator:
Diane Barrett, UC Davis

Co-Principal Investigator:
Jinru Chen, University of Georgia
Lisa Kitinoja, World Food Logistics Organization

Collaborators:
Marita Cantwell, Michael Reid and Veronique Bikoba, UC Davis
Dan MacLean and Robert Shewfelt, University of Georgia
Symantha Holben, Farbod Youssefi and Lizanne Wheeler, World Food Logistics Organization

Tanzania
Co-Principal Investigator:
Ngoni Nenguwo, AVRDC

Collaborators:
Bertha Mjawa and Ester Meela, Ministry of Agriculture and Food Security

Key accomplishments

- 36 postharvest specialists (53% women) from 7 countries in sub-Saharan Africa trained in running postharvest training programs
- These 36 specialists extended postharvest information and training to approximately 16,000 smallholder farmers and village level food processors in their home countries
- M&E shows that people who received this training are using their new knowledge and skills
- The "Small scale handling postharvest manual" for horticultural crops was translated into Swahili
- Postharvest training and services center established in Arusha, Tanzania on the AVRDC campus
- The PTSC shop opened at the Ministry of Agriculture and Food Security in Njiro, Tanzania (5k from Arusha)
- Many postharvest demonstrations set up at the PTSCs in Arusha and Njiro. These included improved packages, field packing, grading/packing stations, small-scale coolers and processing equipment, and more.
- Local trainees and project leaders conducted training programs at the centers, reaching 637 participants (203 men, 407 women)
- Graduate students from UC Davis, University of Georgia, and the AVRDC were involved in postharvest research for the project.
- Many of the 36 postharvest trainees received scholarships for graduate studies, fellowships, awards, project grants, and invitations to speak at conferences.

Project Impacts

Measurement of adoption of improved postharvest practices and the related reduction in food losses, with expected subsequent improvements in income was undertaken during 2013, but since the project got such a late start, we mainly have anecdotal reports.
M&E field visits, observations and interviews were undertaken by Lisa Kitinoja (LK) during August 2013 in and around Arusha. Focus group meetings were held with 4 of the many groups who had attended various training programs at the PTSC during PY3. During the focus groups, LK learned about adoption rates, reported impacts, and what follow up postharvest training the groups wanted.

Lessons Learned

The project leaders offer the following recommendations to USAID, Horticulture CRSP and AVRDC:

- USAID should seek out and work with the postharvest specialists trained during this Horticulture CRSP project, as well as the 50 others who have been trained to date via PEF e-learning programs. Each of these 86 postharvest specialists has expertise and field work experience in loss assessment, postharvest demo design, training program implementation and PTSC design.
  - As PIs on future projects in their countries
  - As independent consultants hired to work on current or future projects that involve loss assessment, postharvest handling, food safety, value chain development, capacity

building and/or extension systems development
- As postharvest trainers of persons involved in USAID Feed the Future projects

USAID should support and strengthen the PTSC by
- including the continuation of postharvest training as one of their Feed the Future activities in Tanzania
- promoting the PTSC via strong linkages with Feed the Future's Innovative Agricultural Research Initiative (iAGRI), which is improving food security and agricultural productivity in Tanzania by strengthening the training and research capacity of Sokoine University of Agriculture and the Tanzanian National Agricultural Research System. To help accomplish this goal, iAGRI is sponsoring 120 Tanzanian students in their pursuit of advanced degree training in agriculture and nutrition at a consortium of six U.S. universities led by The Ohio State University (OSU), as well as universities throughout Africa and other parts of the developing world. http://www.feedthefuture.gov/country-tagged-content/tanzania

USAID and Horticulture CRSP should promote the set-up of new PTSCs in developing countries
- More than 80 PTSC designs have been developed by our Horticulture CRSP ToT groups and PEF e-learners who have already identified suitable sites, partners and local costs
- Each and every farming community would benefit from having a local postharvest training and services center

AVRDC – Regional Center for Africa should actively promote the PTSC and continue to implement postharvest training events, workshops and programs at the PTSC in Arusha.
- Offer postharvest training as part of existing projects
- Offer training programs on a contract basis to local organizations involved in postharvest horticulture (TAHA, TAPP, OIKOS, African Development Bank, Horti-Tengeru, etc.) at a set fee to cover associated expenses
- Prior to initiation of these trainings, AVRDC needs to establish fixed prices for training (by the hour and day), renting the PTSC alone, costs for use of specific demonstration materials, labor costs for administrative and technical personnel, etc.

AVRDC should donate any unused/unneeded postharvest tools/good/supplies left in stock at the PTSC at the end of this project as in-kind contributions to MAFS/Njiro
- For use on site in Njiro for postharvest extension work and training programs
- To sell to Tanzanian farmers and small-scale food processors

AVRDC should actively pursue follow-up postharvest projects (research, extension, training and capacity building) in Tanzania and other regions where they are active.
- First, by completing the research activities that were intended to take place as a part of this project. Six topics were identified, and a Research Assistant was hired to conduct this work. A no-cost extension has been granted until June 30, 2013 to allow time for AVRDC to complete this last element of the project.
- By developing new proposals as opportunities arise in collaboration with existing partners (UCD, WFLO, UGA, MAFS) and potential new partners (OIKOS, TAPP, US land grant universities)
- By offering annual postharvest workshops for scientists and extension workers in the region (with registration fees to cover costs)

- By hiring the postharvest specialists trained during this project as trainers and independent consultants

Future projects modeled upon the PTSC developed under this project must include all five components as originally designed in order to make the PTSC financially sustainable
- Training of postharvest trainers (including loss assessment, demo design)
- On-site postharvest training and demonstrations
- Adaptive research, including cost/benefit analyses of potential postharvest innovations
- Postharvest Shop (with tools, goods, supplies) open to the public
- Postharvest services for fees (ex: grading, packing, storage, transport, marketing advice)

Capacity Building

Postharvest trainees
- 36 people (19 women and 17 men) from 7 countries in Sub-Saharan Africa completed the postharvest training of trainers program. The participants represented private businesses, universities, and national research organizations in their home countries. These trainees trained over 16,000 people directly, and reached many more people through the multiplier effect of their training participants training additional people.
- 4 members of the ToT group were hired as independent consultants by AVRDC to provide postharvest training at the PTSC during 2012-2013.
- 3 members of the ToT group were hired as consultants and postharvest researchers by a Horticulture CRSP funded project in Uganda.
- 3 members of the ToT group were hired as consultants for AVRDC's new postharvest losses project.
- 1 graduate of the ToT program is currently studying for a PhD in France.
- ToT participants are still in mentoring relationships with project leaders, and are also serving as mentors for others.
- Two female trainees received AWARD fellowships.

Other training
- 637 farmer association members, food processors and traders, and women's cooperative members (230 men, 407 women) attended a series of postharvest training programs led by project leaders, the 36 postharvest trainers and other local postharvest trainers. The training topics included general postharvest technologies for horticultural crops, solar drying of fruits and vegetables, food processing and food safety, management and marketing and more.
- Visiting project scientists provided ongoing training and support through workshops at demonstrations at the PTSC.
- 600 people attended training programs held by the PTSC (either on or off site). 933 additional people visited the PTSC but did not attend a training.
- 50 people trained through the Postharvest Education Foundation's e-learning program.

Student training
- The project partially funded one master's student at the University of Georgia.
- 63 Tanzanian diploma students attended a 2-day training on general postharvest handling practices.

Sustainable Development of Horticultural Crops in Zambia by Introducing Postharvest Technologies and Practices for Food Security, Income Generation and in Support of the Tourism Industry

Project Description

The goal of this project is to increase food security and generate income for rural farmers through quality production of vegetables. This project enables these communities to have access to appropriate germplasm and involves them in the production, post-harvest handling and commercialization of high value produce to diversify their incomes. Growers also are trained in greenhouse tunnel construction and systems to produce vegetables in open field and under more controlled greenhouses are compared. Access to information is an important component of this project. Farmers are trained not only in production, commercialization of fresh produce but also on business skill development and constraints noted in other communities. This project impacts 100 farmers (55% women) from the communities in the Livingstone region to produce 100 metric tons of vegetables valued of $125,000. This project uses our market-first science-based approach involving private sector buyers, including the Zambezi Sun, Royal Sun, Spar and Shoprite supermarkets, David Livingstone Hotel, Chrismar Hotel and lodges in Livingstone with whom we partner.

Collaborators:
U.S.
- Professor James E. Simon, Principal Investigator

Zambia
- Bismarck Diawuo, Country Director, ASNAPP-Zambia

South Africa
- Elton Jefthas, Country Director, ASNAPP-South Africa,
- Petrus Langenhoven, Agronomist / Greenhouse Specialist

Key Accomplishments:

- During the reporting period, on-farm training on the production of vegetable seedlings using greenhouse technology was conducted and 15330 seedlings were produced and sold to the value of $1522.
- Crops sold to the Livingstone market reach 1158 tons to the value of $2,034,047
- Conducted field visits with 14 farmer groups with a total number of 274 (female 211, male 63) growers for technical back-stopping in the area of improved production techniques.

Capacity Building:

Workshops and farmer training:
Two researchers (Bernard Moonga and Moses Banda) from the University of Zambia (UNZA) attended a postharvest training course at the AVRDC in Tanzania. Both UNZA researchers also attended a one-week intensive hands-on training program at the Horticulture CRSP Innovation Center in Arusha, Tanzania.

A total of two hundred and thirty-one (231) farmers were trained (48 male and 183 female).Farmers received training in the following areas:

- Seedling production: 20 farmers (3 male, 17 female)
- Irrigation management: 24 farmers (6 male, 18 female)
- Postharvest technology: 24 farmers (6 male, 18 female)
- Crop Rotation: 16 farmers (16 female)
- Marketing: 12 farmers (7 male, 5 female
- Compost making : 15 farmers (0 male, 15 female)
- Record Keeping : 24 farmers (8 male, 16 female)
- Land preparation: 28 farmers (10 male and 18 female)
- Planting techniques: 12 farmers (0 male and 12 female)
- Safe handling of chemicals: 5 female farmers
- Harvesting: 15 female farmers
- Leadership/Record keeping: 29 farmers (8 male and 21 female)
- Seed sowing: 7 farmers (0 male and 7 female)

Presentations and Publications

2014. Coppin, J., H.R. Juliani, Q.L. Wu and J.E. Simon. Variation in polyphenols and lipid soluble vitamins in Moringa oleifera, pp 12. In: Preedy, V.R. (ed). Processing and Impact Active Components in Food, Elsevier Press (in press).

2013. Villani, T., H.R. Juliani, Q.L. Wu and J.E. Simon. Hibiscus sabdariffa: Phytochemistry, Quality Control and Health Properties, pp. 209-230. In: Juliani H.R., J.E. Simon and C.T. Ho (eds). African Natural Plant Products. Volume II: Discoveries and Challenge in Chemistry, Health and Nutrition. American Chemical Society Symposium Series 1127, ACS Press, Washington, D.C. USA (in press).

2013. Coppin, J.P., Y.P. Xu, H. Chen, M.H. Pan, C.T. Ho, H.R., Juliani, Q.L. Wu. and J.E. Simon. Determination of flavonoids and anti-inflammatory activity in Moringa oleifera by LC/MS. J. Functional Foods (in press).

Developing Training Materials to Improve Postharvest Practices in Central America

Project Description
We propose to develop and produce audiovisual training materials on various key postharvest topics, including narrated PowerPoint presentations and short videos. We will incorporate into the PowerPoint presentations illustrations of the concepts and practices being presented via time lapse photography and short video clips that show the actual practice or change in product appearance occurring. The training materials will be developed in consultation with Horticulture CRSP leaders and participants in order to take advantage of the insights and experience they have gathered working with their projects' clientele.

Collaborators:
USA
- Jeffrey Brecht and Mark Ritenour, University of Florida
- Luis Cisneros-Zevallos, Texas A&M University

Key Accomplishments:
- Project team made contacts with potential in-country partners (Subject Matter Experts, etc.)
- Project plans adjusted based on information gathered on trips to Guatemala and Honduras.
- List of potential subject matter experts (SMEs) compiled, topic online created for use in SME recruitment
- SMEs for 7 of the 12 topics have verbally agreed to participate.

Narrative
Our first activity was a trip to Guatemala and Honduras from 12-17 August by the three co-PIs and Horticulture CRSP Assoc. Dir. Amanda Crump. Guatemala and Honduras are the countries for which we will be creating the training materials that are the subject of our project. We met with USAID personnel, faculty at UVG in Guatemala and Zamorano in Honduras, agriculture sector companies, and the Guatemalan export association. Our goal for this trip was to learn about the agricultural systems in the two countries from subsistence farmers to exporters and to find out from people with experience working with horticultural producers how best to transfer knowledge and tools to improve their success. We also described our proposed project and solicited feedback form everyone with whom we met. As a result of the trip, we gained insight into how the modules of the training presentations should be structured to best benefit producers with different levels of sophistication.

Upon returning from Guatemala and Honduras, the co-PIs discussed moving forward to recruit Subject Matter Experts, specifically following up on an idea from our trip to jointly create the first presentation outline ourselves in order to have a sample that would help the potential SMEs understand what we are looking for. We chose the topic, "Harvesting to Avoid Injuries" and put that together.

We had a conference call with Horticulture CRSP personnel on 5 September in which we shared our experiences and new insights and discussed how we would move forward. The draft outline for the Harvesting presentation was shared and reviewed.

PI Brecht visited with Mark Bell at the Horticulture CRSP offices on 24 September and discussed how to incorporate short video clips and time-lapse photography into the narrated PowerPoint presentations. We also discussed our insights from Guatemala and Honduras and how those relate to adult learning and creating effective presentations.

After finalizing the Harvesting outline, the co-PIs discussed and agreed on our plan for recruiting SMEs (including deliverable timeframes/deadlines), re-visited the names of potential SMEs that we had previously compiled, and began contacting the potential SMEs.

Delivering Food Safety Education Through Social Networks in Guatemala, Honduras, Nicaragua

Project Description

Contamination of vegetables with food borne pathogens and spoilage organisms results in food borne illness and economic losses. This problem is worldwide, but is particularly serious in Central American countries that are already fighting problems due to poor nutrition and poverty. Despite the potential magnitude of the problem, small-scale Latin American farmers are generally unaware of these hazards and losses and how these risks can be prevented. The lack of awareness of these risks (and potential benefits realized by their control) complicates communication efforts on the subject and hinders the sustained adoption of safe agricultural practices in horticultural production. We hypothesize that established social networks will provide an effective and efficient venue to communicate vegetable microbial contamination information and promote management changes to improve produce safety and quality. We will test this hypothesis using several social networks (greenhouse associations, organic production associations, health clinics, schools, and traditional Extension outreach programming) to communicate food safety and quality messages. These networks are particularly relevant as they are expected to include a large proportion of female farmers. Increases in awareness among farming communities in Honduras, Guatemala, and Nicaragua will be measured. Successful pathways of communication will be expanded and adoption of food safety practices assessed. At the completion of these participatory research and outreach activities, several tangible goals will be accomplished: Food contamination will decrease, farmer health and produce quality will be improved among participants; new opportunities for sale and trade of produce will be opened, increasing economic viability for farmers; and a model system for effective delivery agricultural assistance in Latin American countries will be validated. These methods can then be applied to communicate other important information to enhance crop production, microfinance, or additional nutritional education.

Collaborators:

USA
  Principal Investigator:
  Jeff LeJeune, The Ohio State University
Honduras
  Co-Principal Investigators:
  Alfredo Rueda and Yordana Valenzuela, Zamorano University
Nicaragua
  Co-Principal Investigator:
  Julio Lopez, PROMIPAC Nicaragua
Guatemala
  Co-Principal Investigator:
  Eduardo Pretzanzin, Universidad de San Carlos

Key Accomplishments:

- Needs assessment conducted
- IRB approved
- Julio Lopez joined the team as the primary contact at Zamorano

Narrative

IRB approval has been obtained through Ohio State (Continuing Review documents are currently being evaluated) and Eduardo Pretzanzin has been approved as an individual investigator. During the long IRB process, our primary contact at Zamorano, Alfredo Rueda, left the university leaving us with no alternate contact. We have since reached out to Zamorano and have a replacement as the primary contact. Julio Lopez has agreed to be this person. Travel plans have tentatively been set for October 14-19, 2013.

Strengthening value chain for African Indigenous Vegetables in Kenya, Tanzania, Zambia

Project Description

Our research seeks to support and strengthen the African Indigenous Vegetables (AIVs) industry using a market-first approach to overcoming constraints along the value chain leading to improved production practices, supply, postharvest handling, distribution and consumer acceptability of AIVs in Kenya, Tanzania and Zambia. Key ingredients are development of a strong public: private sector partnership that ensures activities support needs of consumers and markets and involve germplasm evaluation, development of sustainable production and seed production/saving techniques, improved market access and building capacity of stakeholders through outreach programs at all levels of the AIV value chain. This project will both characterize nutritional attributes of AIVs as well as create awareness of health and nutritional benefits of AIVs through household and market surveys and educational programs about nutrition. We will bridge information gaps through research and promotional activities cooperating with private sector, farmer groups, government, research and NGO communities to build confidence in AIV production and enhancement of farmer adoption of AIV systems. Our activities will build capacity of African universities and institutions involved in research and training of extension personnel who serve the farm community. Improved AIVs will provide nutritional complements to diets. The approach is tailored to local dietary needs and promotes biodiversity and sound environmental management in production while providing affordable edible foods that can be grown and consumed locally or processed. Activities will result in improved income generation, new microenterprises across the value chain, improved availability of nutritious AIVs for consumption and overall improved quality of life.

Collaborators:

Principal Investigators – U.S.A.
Dr. Stephen C. Weller and Dr. Maria Marshall, Purdue University
Dr. James E. Simon, Rutgers University

USA Collaborators:
Dr. Steve Yaninek, Dr. Betty A. Bugusu, and Dr. M. Fernanda San Martin-Gonzalez, Purdue University
Dr. Qingli Wu and Dr. Rodolfo Juliani, Rutgers University

Kenya
Co-Principal Investigator
Dr. Pamela Obura, AMPATH Center at Moi Teaching and Referral Hospital / Moi University,

Kenya Collaborators
Dr. Elizabeth Omami, Dr. Julius Ochuodho, Dr. Linnet Serenge Gohole, Dr. Violet Kadenyeka Mugalavai and Dr. Wilson Ng'etich, Moi University
Christine Ndinya and Dr. Martins Odendo, KARI
Naman Nyabinda, AMPATH/FPI

Tanzania
Co-Principal Investigator
Dr. Chris Ojiewo, AVRDC-The World Vegetable Centre

Collaborators
Dr. John Msuya and Dr. Joyce Kinabo, Sokoine University of Agriculture
Mrs. Nancy Kaaya, Horticulture Research Institute
Dr. Don Lotter, St. John's University of Tanzania

Key Accomplishments:

- AIV variety trials conducted in Livingstone and Lusaka (Zambia); trials will be repeated next year.
- 200 baseline household surveys conducted in Livingstone and Lusaka
- The major markets for AIVs in the Lusaka area were mapped
- Zambian farmers were trained on the best agricultural practices for AIVs, irrigation management, postharvest technology, harvesting and postharvest handling, marketing, soil improvement, data collection, land preparation, and good planting practices. 205 farmers in total attended at least one training.
- In Kenya, field trials were held to study the impact of different fertilizer types on the type and number of insect pests of AIVs, the impact of fertilizer type on AIV growth, and the impact of fertilizer type on AIV seed production and quality
- In Kenya, an MS student conducted a research project on improved solar drying for AIVs
- Baseline household surveys and vendor and consumer choice surveys were conducted in Kenya
- Nutrient composition of AIVs was analyzed
- A postharvest market survey was conducted in Tanzania
- Multiple university professors and graduate students in Kenya and Tanzania are involved in research related to the project, in line with the project's objective of building capacity of key research personnel and graduate students

Capacity Building

In Zambia, 205 farmers (23 male, 182 female) were trained on the following topics:

- Land preparation, seed placement, crop establishment, weeding, scouting, pest and disease identification and management –39 farmers (9 male, 30 female) in Livingstone attended a training on how to produce quality amaranth, nightshade and spider plant products that meet the expectations of the market. A similar training was held in Lusaka with the Mitengo Woman's Association where 27 women were trained during February 2013.
- Irrigation management – During November, training was provided to 24 farmers (6 male, 18 female) in the use of a tensiometer when scheduling irrigation of crops. The training included practical demonstrations.
- Postharvest technology – During November, training was provided to 24 farmers (6 male, 18 female) in the postharvest handling, washing and cooling of products. Food safety and hygiene also formed a key component of the training. The training was conducted in partnership with Sun International Hotel.
- Harvest and postharvest handling- 35 farmers (0 male, 35 female) were trained during January on the importance of harvesting techniques and further emphasis was placed on postharvest handling, washing and cooling of products.

- Marketing - 24 farmers (0 male, 24 female) were trained in marketing during February. Emphasis was placed on quality products, consistency, timeliness and types of packaging. The concept of demand and supply in relation to price was explained as well.
- Production and Marketing – 30 farmers (1 male and 29 female) in Lusaka were trained on the production and marketing of AIVs during February 2013. Emphasis was placed on the correct production techniques and harvesting procedures for AIVs. The marketing of AIVs was discussed. Several enterprise development issues were discussed as well with specific reference to the importance of record keeping and traceability of food products from the farm to the market
- Postharvest handling and cold storage – 27 farmers (1 male and 26 female) were trained in Lusaka in the postharvest handling and cold storage management of AIVs. Harvesting techniques and cold chain management and the associated reduction in postharvest losses were discussed.
- Soil improvement - Crop rotation – 13 farmers (0 male and 13 female) were trained in crop rotation practices during April 2013. Emphasis was placed on the benefits of crop rotation and which crops to use. The use of cover crops, green manure crops and leguminous crops were promoted.
- Data collection – Two male staff members responsible for the AIV trials were trained in data collection during July 2013. Emphasis was placed on timely and accurate data collection methods. The data collection templates were explained.
- Land preparation – During August 2013, 9 farmers (0 male and 9 female) were trained in how to sharpen a hoe and to make most effective use of a hoe while preparing land. A garden fork, introduced by Ms. Laura Bush, was also discussed and the use thereof demonstrated.
- Sowing of seeds – 8 farmers (0 male and 8 female) were trained in the correct sowing methods and rate for amaranthus, spider plant and nightshade during August 2013.
- A nutrition and cooking class was also held to teach people how to best prepare AIVs. Farmer training included both class lectures and practical, hands-on exercises, and farmers also participated in field days and a seed fair. 149 farmers (75 male, 74 female) attended field days near Arusha, Tanzania, and 269 farmers and horticultural students (104 female, 165 male) attended a 2 day seed fair in Tanzania

In Kenya, 615 farmers (143 male, 472 female) were trained on AIV production and planting technology, and 276 (79 male, 197 female) were trained on crop management, pest management, harvesting, and seed saving. 50 FINTRAC collaborators also participated in both Kenya trainings.

Student training

- Four US Ph.D. students (3 male, 1 female) assisted with the project (part time, hourly work). In addition, 5 Kenyan M.Sc. students (3 male, 2 female) are working on the project (full funding). 2 US undergraduates also worked as summer interns on the project.

Awards (Simon)

- 2013 International Excellence Award Recipient for 2013, School of Environmental and Biological Sciences. Rutgers, The State University of New Jersey. Based upon international development work in sub-Sahara Africa.

- 2012 Recipient of the 2012 Award for Scientific Excellence by a researcher in a USAID Collaborative Support Research Program. The Board for International Food and Agricultural Development (BIFAD), USAID.
- 2012 Recipient of the 2012 Burton Kallman Scientific Award, Natural Products Association. This award recognizes individuals who have made outstanding scientific contributions that have benefited the natural products industry.

Presentations and Publications

Simon, Weller, Marshall and Langenhoven participated in the Horticulture CRSP annual meeting in Nairobi. Our team presented a poster at the annual Horticulture CRSP meeting and later displayed the poster at the opening of the Horticulture CRSP Innovation Center at KARI Theka. In addition, Weller (Purdue), Simon (Rutgers), Marshall (Purdue), Langenhoven (ASNAPP) and Yaninek (Purdue) each spoke at the Horticulture CRSP Innovation Center at KARI Theka providing an overview to this Horticulture CRSP project as well as the African Indigenous Vegetables project.

In addition, the project team presented on "Quality and nutritional assessment of African Indigenous Vegetables (AIVs)" at the American Council for Medicinally Active Plants 4th Annual Conference in Amherst, MA from June 2-5, 2013.

List of Anticipated Research Papers, Technical Manuals and Other Evidence of Science-Based Research in the International Horticulture CRSP projects.
AIV-Purdue led, Rutgers-co-PI role (Project in 2nd and 3rd year):

1. Household survey of foods for food security and popularity including the role, if any, of AIVs in Zambia [Led by Martins/Marshal, Eldoret and Purdue with Rutgers]; *Status: data collected, paper draft in process.*
2. Household survey of foods for food security and popularity including the role, if any, of AIVs Kenya [Led by Martins/Marshal, Eldoret and Purdue with Rutgers]; *Status: data collected, paper draft in process*.
3. Postharvest handling and marketing: A case study of AIVs in Tanzania [Led by Don Lotter, with Purdue and Rutgers]. *Status: data collected, data set confirmed*.
4. Household survey of African Indigenous Vegetables in Zambia: A case study. [Led by ASNAPP and Purdue, with Rutgers]. Status: field data being collected now.

5. Marketing of AIVs in Kenya and Zambia: A comparative examination. [Led by ASNAPP and Purdue, with Rutgers]. Status: field data being collected now.
6. Seed production and quality of African Indigenous Vegetables in Kenya. [Led by KARI, with Elodret University and Purdue University]. Poster presented at Horticulture CRSP, and data set collected.
7. Impact of Fertilizer on growth and yield of Amaranth, Spiderplant and Nightshade. [Led by Eldoret University with Purdue and Rutgers]. Poster of graduate student thesis work presented at Horticulture CRSP. Data set collected. Data needs to be confirmed.
8. Impact of Water Management and Irrigation on growth and yield of Amaranth, Spiderplant and Nightshade for continuous production. [Led by Eldoret University with Purdue and Rutgers]. Poster of graduate student thesis work presented at Horticulture CRSP. Data set collected. Data needs to be confirmed.

9. Impact of Fertilizers on growth and yield of Amaranth, Spiderplant and Nightshade. [Led by Nancy, Tanzania with Purdue and Rutgers]. Data set collected. Data needs to be confirmed.
10. Presence and control of insect pests on Amaranth, Spiderplant and Nightshade. [Led by Eldoret University with Purdue University, involves a graduate student].
11. Integrated pest management approaches for production of Amaranth, Spiderplant and Nightshade. [Led by Eldoret University with Purdue University, involves a graduate student].
12. Nutritional characterization of dried African Indigenous Vegetables. [Led by Rutgers, in concert with Kenyan and Zambian partners, with Purdue]. Antioxidant activities, total phenols, proximate analysis completed, total carotenoids and tocopherols in process.
13. Rapid field detection method for alkaloids. [Led by Rutgers University, involves a Rutgers graduate student, with in country partners from Kenya and Zambia and Purdue]. Poster presented at Horticulture CRSP, and data set collected. HPLC work completed, MS completed. Modifications to rapid screen underway to reduce sensitivity to link detectable limits relating to health recommendations.
14. Nutritional characterization of amaranth germplasm. [Led by Rutgers, in concert with AVRDC and Purdue, PhD graduate student from Rutgers]. Status: research in process.
15. Water use efficiency and population differences of water stress tolerance among amaranth, nightshade and spiderplant under controlled conditions [Led by Purdue, in concert with Rutgers. Involves an MS graduate student from Purdue]. Status: research in process. Differences in tolerance to water stress identified among populations].
16. Nutrient and Phytochemical content as varied by variety, geographical location, harvest time and production systems. [This is a group effort to link production systems to nutrient and phytochemical content and is ongoing. Will not be completed till Year 3 of this project].

<u>Leveraged publications already accomplished with partnering organizations (G=Graduate student involvement):</u>

1. 2013. Ray-Yu Yang and Chris Ojiewo. African Nightshades and African Eggplants: Taxonomy, Crop Management, Utilization and Phytonutrients and Alkaloids. In: Juliani H.R., J.E. Simon and C.T. Ho (eds). African Natural Plant Products. Vol. II. American Chemical Society ACS Symposium Series, ACS Press, Washington, D.C. USA (in press). [Led by AVRDC]
2. 2013. Ray-Yu, and Sahrah Fischer, Peter M. Hanson, and J. D. H. Keatinge. Increasing Micronutrient Availability from Food in Sub-Saharan Africa with Indigenous Vegetables. In: Juliani H.R., J.E. Simon and C.T. Ho (eds). African Natural Plant Products. Vol. II. American Chemical Society ACS Symposium Series, ACS Press, Washington, D.C. USA (in press). [Led by AVRDC]
3. Villani[G], T., H.R. Juliani, Q.L. Wu and J.E. Simon. *Hibiscus sabdariffa*: Phytochemistry, Quality Control and Health Properties. In: Juliani H.R., J.E. Simon and C.T. Ho (eds). African Natural Plant Products. Vol. II. American Chemical Society ACS Symposium Series, ACS Press, Washington, D.C. USA (in press). [Led by Rutgers]

<u>Zambian Horticulture CRSP Rutgers led, with Purdue as co-PI role (Project began Feb., 2012, about 1.3 years ago):</u>

1. Constraints to postharvest handling of fresh produce: a status of the cold chain in Zambia. [Led by Stellenbosch University and Rutgers University, with Purdue University, field data collected by ASNAPP,]. Status: field data being collected now.
2. Utilization of plastic recyclable containers to improve shelf-life, reduce bruising and increase health and sanitation with fresh produce. [Led by Stellenbosch University and Rutgers University, with Postharvest Education Foundation and Purdue University, field data being collected now by ASNAPP]. Status: field data being collected now.
3. With the CoolBot and ShadeBots being built now in Livingstone, costs of their construction and utilization (energy costs and inputs costs vs. price differentials and volume of produce sold) and role to empower small-holder growers and associations will be monitored. Research has not begun- units and facilities being built in year 2.
4. A market-first science driven model to create income generating opportunities using fresh vegetable for small-holder farmers: A Case Study from Zambia [Led by ASNAPP-Zambia and Rutgers University]. Status: Manuscript outline drafted but paper not yet written.

Creating a market niche for "food-safe" vegetables in Cambodia, Vietnam

Project Description

The rapid economic and population expansion of Cambodian and Vietnam within the greater SE Asian region presents opportunities for impacting the livelihood of many people where horticulture remains an important undeveloped business sector supported by small farmers. Our goal is to empower small farmers (59% of whom are women) with integrated experiential education and training for sustainable vegetable production that limits postharvest losses, increases food safety, increases market access and, importantly, increases income. We have designed an innovative participatory approach to meet these goals by networking experts in horticulture production through marketing. The inclusiveness as stakeholders of farmers' communes, regional universities, local governments and national communications companies in the network provides continuity needed for continuation of farmer outreach training and education beyond the lifetime of USAID Horticulture CSRP funding. The successful completion of the project in Vietnam will serve as a model for implementation of the participatory action network in other, more challenging, countries like Cambodia and Laos with similar, but less developed, horticulture business sectors. Importantly, completion of this project will address essential capacity-building needs of Cambodia including an assessment of capabilities, research training, outreach development and promotion of communication between policy makers, universities and the agribusiness community. A direct impact from this project is that Cambodian and Vietnamese vegetable farmers will gain income.

Collaborators:

USA:
Principal Investigator
Cary Trexler, UC Davis

Co-Principal Investigators
Glenn Young and Johan Six, UC Davis

Collaborators:
Mark Van Horn and G. David Miller, UC Davis

Vietnam
Co-Principal Investigators
Vong Nguyen, Hanoi University of Agriculture
Tam Pham, Nong Lam University

Collaborators:
Hien Lam, Tam Minh Pham, Hoa Thai, Nong Lam University
Thuy Nguyen, Huong Pham, Duong Pham, Hung V. Pham, Hanoi University of Agriculture

Cambodia
Co-Principal Investigator
Borarin Bungtong, Royal University of Agriculture

Collaborators:
Thong Kong, Lyda Hok, Asikin Yoeu and Lor Lytour Royal University of Agriculture

Key Accomplishments:

- A series of Farmer Field Schools were conducted focused on topics ranging from savings groups to bio-pesticides and muskmelon and cool season crop production.
- In Hanoi, farmers who participated in the Farmer Field Schools are earning $100 more per sao (60x60 meters^2) than average, and demand for training in these new practices has increased.
- At Nong Lam University, a growers' cooperative participated in a farmer field school about postharvest handling of horticultural crops. Farmers are now trained in proper handling techniques, and the cooperative has a contract with a supermarket.
- UC Davis faculty held a workshop on grant writing for RUA faculty. Following this workshop, RUA was awarded a $100,000 grant by the World Bank to set up a Safe Vegetable Center.
- 60 farmers, traders, and local authorities in Cambodia were interviewed about production, postharvest, transport, economic and marketing needs.
- 4 one day Participatory Action Research workshops were held with farmers
- Honeydew variety trials conducted at the Royal University of Agriculture
- 15 RUA students conducted surveys and focus groups about seasonality in horticultural production activities in villages, including seasonal market changes and fluctuating availability of inputs. This information contributed to the design of a baseline survey for the savings group sub-project. The baseline survey was has been completed in 10 villages.
- One RUA team member and two RUA students were trained to become Savings for Change facilitators.
- 14 savings groups formed in Cambodia as part of the Miller sub-project
- The project's research findings were presented at a Cambodian AGRINATURA research workshop and at the Horticultural CRSP annual meeting
- 70 RUA students and 15 faculty members attended a technology training session put on by the Kasetsart Center. The training was also attended by Vietnamese project partners and private industry representatives.

Capacity Building

Farmer Field Schools:
Farmer Field Schools were held at 2 locations in Vietnam. No data was provided on the number of participants.

Kasetsart Training:
In July, trainers from the Horticulture CRSP Regional Center of Innovation at Kasetsart University (Thailand) came to RUA (Cambodia) to train project team members, RUA students and RUA faculty on low-cost, easily adapted technologies such as solar drying, soil solarization, solar-powered, drip irrigation, drying beads, and more. The training was attended by 16 Vietnamese project team members and private industry representatives (10 men, 6 women) and 120 Cambodians (80 men, 40 women), the majority of whom were students or faculty at RUA.

Student training:
The project has fully or partially funded 37 (15 men, 22 women) bachelor's and master's degree students at Nong Lam University, Hanoi University of Agriculture, and the University of Agriculture and Forestry (all in Vietnam). In addition, 15 students from the Royal University of Agriculture (Cambodia) were trained to conduct village surveys. One RUA team member and two RUA students were trained to become Savings for Change facilitators

Presentations and Publications

Two papers from the project with Hanoi University of Agriculture are currently under review in refereed journals. Four papers are in preparation to share the results of research conducted in HCMC.

In January we presented our proposed research at The Cambodian AGRINATURA Research Workshop on Integrated Agriculture and Natural Resource Management for Sustainable Development. We had an audience of 60 people including RUA students and faculty and representatives from various local and international organizations.

In May Frederik Sagemuller presented our research at the annual Horticulture CRSP conference in Nairobi, Kenya.

Strengthening the value chain for orange- and purple-fleshed sweet potatoes in Ghana

Project Description

In Ghana, the prevalence of vitamin A deficiency is high among children and pregnant women. Vitamin A deficiency (VAD) affects 72% of the country's children under five population and contributes to one out of three of all child deaths between the ages of 6 to 59 months. The projected number of childhood deaths attributed to Vitamin A deficiency will be 104,300 between 2005 and 2014.

Sweet potato is considered an excellent food security crop in sub-Saharan Africa. Although high in carbohydrates, white sweet potatoes mostly consumed are very low in beta-carotene, precursor to vitamin A. Widespread production and consumption of the vitamin A-rich orange and purple sweet potatoes in Ghana still remains limited due to lack of awareness, limited availability of clean-planting materials and limited inclusion in the diet for diversity.

Using the gap and decision analysis tools, "The Sustainable Technologies for Orange and Purple Sweet potatoes (STOPS)" project proposes to strengthen the value chain in three sweet potato growing regions in Ghana to improve food security, agricultural productivity and economic value. This aligns with the themes and related strategic emphasis of the Horticulture CRSP and USAID Feed the Future Initiatives in Ghana as a focus country.

Throughout the chain analysis, gender and the status of children will be given elevated consideration to ensure the participation and benefit to women and children from project services and outcomes. By working with most of the actors along the value chain, this research has the potential to enhance the economic opportunities especially among resource-poor sections of the rural population.

Collaborators

USA

Dr. Eunice Bonsi, Dr. Conrad Bonsi, Dr. Desmond Mortley, Dr. Robert Zabawa, and Dr. Prosper Doamekpor; Tuskegee University

Dr. Leland Glenna, Dr. Thomas Gill, Dr. Janelle Larson, and Dr. Sjoerd Duiker; Pennsylvania State University

Ghana

- Crop Research Institute
- Savannah Agriculture Research Institute (SARI)
- Ministry of Food and Agriculture
- University of Ghana
- Food Research Institute
- University for Development Studies
- Selasie Farms and Groceries
- Adonokope Farmers Association

Key Accomplishments:

- Established a clean sweet potato vine multiplication site at the SARI research site

- Established clean vine multiples sites at two research facilities in the Northern and Upper East Regions in Ghana
- Selected farmers to demonstrate production of clean sweet potato vines and serve as clean vine distributors
- Conducted focus groups on orange and purple sweet potato palatability and preferences with local NGOs and schools
- Established orange and purple sweet potato demonstration gardens at a junior high school, a high school, and NGO sites. Gardeners at the NGO sites expanded the garden by 100% on their own initiative
- Distributed handouts on orange and purple sweet potatoes
- With SARI and UDS, conducted an analysis on products containing orange and purple sweet potatoes currently available in Ghana
- Developed a partnership with 4H Ghana to help promote orange and purple sweet potatoes to youth
- Developed new technologies for sweet potato processing
- Promoted the inclusion of orange and purple sweet potatoes in traditional recipes, some of which were served at the SARI cafeteria
- The Penn State and SARI teams surveyed 540 households in three regions in Ghana to gather baseline information about sweet potato production, the sweet potato value chain, and household food security and demographics
- Focus groups, key informant interviews, and market were held to validate the survey data
- Local bakers are now using locally-grown orange fleshed sweet potato puree to make bread
- Dr. Eunice Bonsi was shortlisted for a "Change Maker for Global Nutrition" Award

Capacity Building

The project fully funded a Masters student at the University of Development studies in Ghana. It also provided partial funding to a Masters student and a PhD student from Penn State.

Presentations and Publications

The project developed several factsheets about orange and purple-fleshed sweet potatoes, which were distributed in Ghana. Formal publications are planned for the final year of the project.

Developing a Participatory Extension Model to Enhance Smallholder Production and Marketing in Democratic Republic of Congo, Uganda

Project Description

Although the growing market for horticultural products in Uganda offers an opportunity for smallholder farmers to improve their income, their access to these markets is still limited. This project will develop a participatory extension model to rapidly improve smallholder linkages to horticultural markets, which will be achieved by merging and supplementing two agricultural development models - Farmer Field Schools (FFS) with the Participatory Market Chain Approach (PMCA). We will work with farmer groups established in our pilot project in Nkokonjeru, Uganda and evaluate the potential of our adapted FFS methodology to a pilot community in the Democratic Republic of Congo. Specific objectives are to strengthen farmer groups' capacity to produce indigenous leafy green vegetables and tomatoes for the market and improve farmers' ability to use their farm as an income generating asset. Research in small plots and on farmers' fields of economically appropriate soil fertility management technologies, including micro-dosing, improved varieties, irrigation, and safe pesticide use, will help identify ways to increase vegetable yields and quality. Curriculum enhancement with a local university (Uganda Christian) and Uganda's primary agricultural university (Makerere), as well as with governmental and NGO agricultural extension, will strengthen the region's capacity to carry out and sustain research and extension activities for horticultural crops.

Collaborators

US
Principal Investigator:
Kate Scow, UC Davis

Co-Principal Investigators:
Johan Six, Mark Van Horn and Heidi Ballard, UC Davis

Collaborators
Stephen Boucher, UC Davis

Uganda Collaborators:
- Edith Naggenda and Ignitius Bwoogi, Rural Agency for Sustainable Development
- Michael Masanza; Uganda Christian University
- Beatrice Akello and Peter Lusembo, NARO-MUZARDI
- Harriet Nsubuga Mpanga, Agribusiness Initiative Trust, Inc.
- Prossy Isubikalu, Makerere University
- Dennis Yiga, Mukono District Local Government

Democratic Republic of Congo
- Karel Van Laer, Scheut Tshilomba

Key Accomplishments:

- Conducted Rapid Market Appraisal of value chains for indigenous leafy greens at major local markets, presented it to local market chain actors

- Market actors discussed ways to strengthen the nakati market chain, and formed three focus groups to explore seed production and processing, fresh production and marketing, and processed nakati products
- The seed production group, Nkokonjeru Seed Farmer Group, joined a farmers group, went through seed production training, and produced 250 kg of seed (mainly nakati). They have gotten contracts to produce 900kg of seed next year, and are providing seeds to NGOs and the government.
- PMCA final event held. 103 people attended, including representatives of national and international agricultural organizations. New AIV products were displayed, MUZARDI shared agricultural information about AIVs, and farmers and agricultural input suppliers had the opportunity to share their knowledge and experience.
- "Farmer's Basket", a popular Ugandan TV program, did a feature on two female AIV farmers' experience with PMCA.
- Five students (2 undergraduate, 3 graduate) are involved in conducting research for the project
- 280 participating farmers from all treatment groups were surveyed; results are currently being analyzed
- 6 Ugandan scientists and technicians have adopted participatory methods in their own projects as a result of the Horticulture CRSP team's work with a Ugandan ZARDI (Zonal Agriculture Research and Development Institute).
- Factsheets on AIV production and marketing created and distributed, brochure on PMCA innovations created
- Curricula developed for undergraduate classes on "Participatory Methods" and "Agricultural Extension"'
- 39 farmer groups drafted constitutions, 39 farmer leaders elected to positions
- 20 farmer groups and 29 individuals were interviewed on market interactions
- a Rapid Market Appraisal for indigenous leafy greens was conducted

Capacity Building

Student Training

Two undergraduate women from Uganda Christian University completed their internship with Horticulture CRSP. These interns participated in a broad range of activities, including assisting in on-farm trials on ISFM, participating in and documenting the PMCA process, conducting open-ended interviews, and participating as enumerators in a household survey. The interns also conducted an exploratory research trial on the effect of incorporating products of charcoal production (biochar) into the soil to investigate residual effects. This trial resulted in the project team developing a larger trial both on station at MUZARDI and on farm.

In addition, 11 people (7 men, 4 women) from RASD, MUZARDI, and Uganda Christian University were trained on how on how to conduct surveys, and they surveyed participants in order to evaluate the project. They earned certificates as the result of their completion of enumerator training.

Overall, 8 Uganda Christian University undergraduates (2 male, 6 female) participated in the project: either as survey enumerators, special project students, or interns.

UC Davis - PhD Research
Lauren Pincus is in the process of collecting her dissertation data in Uganda. She is based in Nkokonjeru, Uganda. In June 2013 she completed the first field season for her two research projects. Her field trial is investigating the effect of organic and inorganic fertility sources across soil types. She harvested from thirty-three plots, each located on an individual farmer's plot of land, and is waiting to process the samples to determine dry weight and nutrient content. Her second research project looks at the internal and external characteristics important in farmer adoption of inorganic fertilizer. For this research she has organized farmer groups in four villages and is holding educational sessions involving hands-on and classroom education on soil fertility management. As of September 2013 she has planted plots for the second season of her on-farm trial and is continuing to meet with farmer groups and gather social science data into their attitudes related to soil and soil fertility.

Makerere University Masters' Research
William Sekamate has finished two seasons of on-station trials comparing different combinations of organic and inorganic fertilizers on Nakati yield (harvestable biomass) and quality (leaf size, height). He has also completed eight on-farm trials and farmer evaluations of the most promising combination of organic and inorganic fertilizers. William is now working with project staff on a trial investigating the common local practice of producing ILVs where charcoal has been burnt. The trial is looking into the residual effects of charcoal production, ash, and charcoal dust. These treatments are combined with fertilizers and compared with agricultural lime and biochar to see if there are common liming effects or interactions with fertilizers. His thesis is in the process of final review and he will graduate in the next few months.

Nassib Mugwanya has completed in coursework for his Masters, as well as research activities documenting the FFS and PMCA process. His study explored ways in which linking two participatory approaches influences how farmers produce and market indigenous leafy vegetables. Qualitative fieldwork reveals notable changes in both production and marketing practices. In production, changes were evident in major crops grown, relative increase in land size allocation, and use of modern agronomic practices. In marketing, changes were in major crops grown for sale, and relative increase in farmers' awareness of market standards for indigenous leafy vegetables. He is in the process of submitting his thesis for final review.

Collaborations with Host Country Research Teams
Horticulture CRSP staff have worked closely with a zonal research and development institute (ZARDI) in the eastern region of Uganda to disseminate FFS practical knowledge. The collaborating ZARDI is interested in nesting a FFS approach within their existing multi-stakeholder innovation platform (MSIP) methodology. Uganda's Ministry of Agriculture has a policy priority to use MSIPs at all levels in the research to extension pipeline. Horticulture CRSP and ZARDI staff have consulted to encourage integration of participatory extension into the ZARDI program. As a result, six scientists and/or technicians in the eastern zone ZARDI have started using participatory techniques to different degrees and have reported the benefits to project staff. PI Scow visited the ZARDI institute to discuss the current status of their research program and the integration of MSIP and FFS methodologies with the director and his staff.

In addition, 10 extension agents were trained as FFS facilitators, and received certificates.

Farmer Training

460 AIV producers (150 men, 310 women) in 24 farmers' groups received training through this project. 10 of these groups were specifically trained in seed production. 20 lead farmers were trained in participatory production, marketing, and farmer group organization, and received certificates. The lead farmers attended workshops on agronomic practices and seed sources, budgeting and farmer group project planning, and participatory monitoring and evaluation.

Developing energy solutions for horticultural production

Project Description

Among the most promising disruptive technologies for application to horticulture are those that address the uses of energy in the production, marketing, and processing of horticultural crops. We propose to test a range of sustainable energy solutions, particularly focused on photovoltaics, and to deploy the most promising at the Horticulture CRSP Centers of Innovation. Technologies that will be discussed for possible testing include:

- D.C. split air conditioner/CoolBot for a solar-powered cool room
- In-village solar panel construction to reduce the cost of photovoltaic supply
- Inexpensive photovoltaic pumping based on R.V. water pumps
- Adsorption refrigeration using Zeolite beads
- High intensity LEDS for a solar-powered germination cabinet
- Vacuum-sealed straw bales for building inexpensive insulated rooms
- Aerogel panels for high-quality insulation
- Peltier-effect cooling for small-scale transport
- Low-cost air suspension for small-scale transport
- Simple solar dryer for fruits, vegetables, and grains
- Facilitated solarization for weed and soil-borne disease control

Collaborators

USA:
Principal Investigator:
James Thompson, UC Davis

Collaborator:
Michael Reid, UC Davis

Key Accomplishments

- Derived equations estimating how long it would take Peltier Blocks powered by a solar panel to cool 100kg of potatoes to 0 degrees C.
- Tested photovoltaic panels and gas generators as possible alternative energy sources for cooling in areas with unreliable electricity in Bangladesh.
- Developed a model predicting energy demand for cooling given different room sizes and types. This will let people know how much solar energy is required and when it is required, so they can make an informed decision about using solar power.
- Calculated cost estimates for several potential solar-powered cooling set-ups (full time cooling, day-time only cooling).
- Tested innovative insulation for coolrooms, including Polyurethane Structural Insulated Panels (SIPs). The project plans to test additional, lower-cost insulation options in the future.
- Commissioned the construction of a small, bike-pulled trailer that can carry a commercial solar or battery-powered cooler/ice chest.
- Tested the amount of time it took for a 10kg bag of potatoes to cool in the cooler, and then tested how long the potatoes retained the cool temperature once the power was removed
- The Thompson-Reid dryer was tested in Pakistan and Uzbekistan.

- The project is currently testing desiccants that could be used to help dry grains and pulses for storage in humid climates

Capacity Building

The project funded a UC Davis student. He assisted with building and testing the project's technologies, and was trained in data collection.

UC Davis D-Lab & Horticulture CRSP Innovation Centers: Providing support & capacity building to bring appropriate technologies to market

Project Description

Among the most promising disruptive technologies for application to horticulture are those that address the uses of energy in the production, marketing, and processing of horticultural crops. This project proposes to test a range of sustainable energy solutions, and to deploy the most promising at Horticulture CRSP's Regional Centers of Innovation.

As part of a larger capacity-building effort, this project will integrate activities at the Horticulture CRSP Regional Centers of Innovation in Thailand and Kenya into ongoing work at the UC Davis D-Lab. UC Davis D-Lab faculty mentors and graduate student teams will collaborate with the Regional Centers of Innovation partners through a structured approach for performing feasibility studies, technical and market assessments, and design development on innovative horticulture-focused energy technologies. Through this process, the centers will gain new methods for evaluating and developing horticulture innovations, better enabling them to attract investment and initiate dissemination of these technologies.

Collaborators

- Dr. Kurt Kornbluth, University of California, Davis
- Dr. Arie Sanders, Director of the Department of Environmental and Development Studies, Zamorano University, Honduras
- Julio Lopez Montes, Director of Innovation Center, Zamorano University, Honduras
- Dr. Siwalak Pathaveerat, Professor, Postharvest Technology, Biological and Agricultural Engineering, Kasetsart University, Thailand
- Dr. Poonpipope Kasemsaap, Vice President for International Relations Kasetsart University, Thailand

Key Accomplishments

- D-Lab I: Energy and Development: An Overview, was offered at UC Davis.
- D-Lab II: Energy and Development: Designing for the Market, was offered at UC Davis.
- Zamorano D-Lab was implemented in Honduras and an evaluation was conducted.
- Kasetsart D-Lab was implemented in Thailand.

Capacity Building

Graduate Student Researchers and Assistants

- Erin McGuire, MS International Agriculture Development
- Nadya Alexander, MS International Agriculture Development
- Tom Stein, MS International Agriculture Development and MS Soils and Biochemistry
- Randall Paul-Cass, MS International Agriculture Development
- Natalie Svoboda, BS College of Engineering

Professional Training:

Design Process and D-Lab Training – Fellowship at U.C. Davis

- Jorge Espinosa, D-Lab Instructor, Zamorano University

Design Process and D-Lab Training, Workshop at Kasetsart University

- Dr. Siwalak Pathaveerat, Professor, Postharvest Technology, Biological and Agricultural Engineering, Kasetsart University, Thailand. Workshop at Kasetsart University.
- Nonglak Samantart, Assistant Director, Professor, Energy and Environmental Engineering Center (EC3)), Kasetsart University, Thailand
- Kietsuda, Professor, Horticulture, Kasetsart University, Thailand

University Capacity and Partnership Building:

- Kasetsart D-Lab, Thailand
- Zamorano D-Lab, Honduras
- UC Davis D-Lab I and II, USA

Presentations and Publications:

1. Draft of Economics of Zeolite Beads for Seed Saving (by Karina Lundahl, Julia Shuck and Sarah Sahlaney)
2. Zamorano D-Lab Evaluation
3. Links to Student Reports on D-Lab technologies:
    - Energy Hub in Uganda
    - Electricity Feasibility Study in Ghana
    - Solar Irrigation in Uganda
    - Seed Saving Feasibility Study in Thailand
    - Solar Fruit Drying in Ecuador
    - Rubber Tapping Knife in Thailand
    - Mobile Irrigation System in Uganda
    - Off-Grid Zeolite Bead Regeneration in Thailand

Horticulture CRSP Associate Award Project Briefs

This year, we report on three Associate Awards:

Assessment of Constraints to Horticultural Sector Growth in the Latin America and Caribbean Region's Feed the Future Focus Countries

- Awarded by the Bureau for Latin America and the Caribbean
- Total award: $460,684
- Award number: AID-OAA-LA-12-00008

Innovative potato storage in Bangladesh

- Awarded by the International Potato Center (CIP)
- Total award: $380,173
- Award number: 16010-000-00-UC DAVIS

Postharvest Training for Central American Smallholder Horticulturists

- Awarded by USDA-FAS
- Total award: $39,960
- Award number: 58-3148-2-168

Advancing Horticulture
Assessment of constraints to horticultural sector growth in Central America

Horticultural crops, particularly vegetables and fruits, are key to increasing food security in the Feed the Future focus countries of the Central American region. With funding provided by an associate award from the USAID Bureau for Latin America and the Caribbean, the Feed the Future Innovation Lab for Collaborative Research on Horticulture conducted an assessment of major constraints to continued growth and increased involvement of smallholder growers in the horticulture sector in Central America, based on looking at two of the region's countries (Honduras and Guatemala). This report identifies constraints to further sector growth in Honduras and Guatemala and recommends research, training, and policy initiatives to address those constraints that have potential relevance to other Central American countries' horticultural sector growth.

The evaluation team was comprised of Dr. Alonso González M. of Colombia, Dr. Tito Livio Zúniga of Honduras, and Dr. L. George Wilson of North Carolina State University, who also served as liaison with the Horticulture Innovation Lab management team. The evaluation included consultation workshops in Comayagua, Honduras and Antigua City, Guatemala, a series of in-person interviews with representatives from all sectors of the horticultural value chain (60 in Honduras and 73 in Guatemala), a web-based survey, and dissemination workshops at La Lima, Honduras and Antigua City, Guatemala. More than 190 people participated in person for interviews and workshops, including representatives of grower associations, trading organizations, financial institutions, input providers, universities, non-governmental organizations, and government. Constraints to the horticulture sector were discussed among the participants at each workshop and opinions were captured for this report. Our findings and recommendations were based on the totality of information collected. Therefore, the prioritization of constraints and recommendations may require adjustment to account for specific local conditions within each country.

Constraints to growth of the horticulture sector and increased participation of smallholder farmers:

Lack of access to adequate and affordable credit and crop insurance

- Without access to credit, smallholder farmers—especially women and indigenous peoples—are limited in their ability to invest in inputs and infrastructure to enhance their crops. Farmers do not invest in inputs for horticultural production due to insecure markets and a lack of funds to invest.

Lack of an adequate extension system

- There are few formal systems for communication of research needs and research findings between smallholder growers and horticultural researchers and research institutions. In fact, there is little transfer of well-established best practices to farmers.

Poor access to high-value markets

- Most smallholder farmers, especially women and indigenous peoples, sell their produce through low-value venues, including direct sales in local markets or selling to intermediaries. Markets are difficult to reach due to distance and poor roads. Prices are volatile and smallholder farmers have little power in dealing with essential intermediaries.

Weather, climate volatility and climate change

- The Central American region is particularly vulnerable to weather-related events (drought, flooding, freezing, strong winds), which impact horticultural production, alter flowering/fruiting cycles and planting dates, increase vulnerability to pests and diseases and often result in severe economic losses.

Pests, diseases, and weeds

- Horticultural crops in the Central American region are subject to attack by an array of pests and diseases, frequently resulting in major losses or intensive use of pesticides. Implementation of the Food Safety Modernization Act in the U.S. may push some smallholder farmers out of the export market due to its strict requirements.

Lack of research addressing regional, national, and local issues of the horticulture sector

- Although a number of quality institutions conduct research and teaching on agricultural production and pest management for the region, targeted research on horticultural crops is limited by lack of financial and human resources. Capacity for research on postharvest and marketing issues is especially low.

Postharvest losses and food safety

- More than 30 percent of the yield of many horticultural crops is lost after harvest as the result of mishandling or the lack of adequate postharvest infrastructure. Moreover, access to international markets requires rigorous attention to food safety.

Key recommendations for research, training, and policy initiatives:

Regional Approaches

1. Promote initiatives to adapt horticulture to climate volatility through better adapted varieties, protected culture, increased access to irrigation systems, and better weather forecasting.
2. Establish regional research programs to address cross-cutting constraints affecting the region, particularly new pests and diseases and sustainable production systems.
3. Promote regional and national training and education programs on appropriate technologies to reduce postharvest losses and comply with the Food Safety Modernization Act (FSMA).
4. Promote regional initiatives to conserve, characterize, and facilitate access to diverse and improved germplasm of horticultural species.

National Approaches

1. Reduce the economic risks to horticulture farmers through availability of effective crop insurance programs.
2. Design and test an interlinked microcredit-index insurance product.
3. Improve national extension systems to ensure research information, best practices, knowledge and technologies are delivered to smallholder farmers.
4. Develop trusts or other microfinance means for financing smallholder farmers, particularly women.
5. Develop national policies to support well-funded, long-term national agricultural research systems (NARS), including training of graduate students.
6. Develop mechanisms to coordinate and enhance the marketing of horticultural products from smallholder growers.
7. Create incentives and an enabling environment to develop horticulture-oriented business services.

8. Develop policies to facilitate the participation of indigenous peoples, smallholders and women in value chains.

Innovative Potato Storage

USAID Bangladesh is providing funds to the Horticulture CRSP through the International Potato Center (CIP). The award funds an activity "Innovative Potato Storage" that is a component of the CIP/AVRDC horticulture project in Bangladesh, and has the overall goal of assisting smallholder potato producers in Southern Bangladesh in improving profitability through access to effective, low-cost table and seed potato storage.
Selection of storage sites:

Based on criteria including area devoted to potato production and experience, willingness to provide land, potential availability of electricity and convenient location, the team decided to construct 8 CoolBot type and 11 ambient (locally-designed) storage rooms in four southern districts - Jessore , Faridpur, Barisal and Potuakhali - during January-April, 2013. Farmer groups were briefed about project goals, their role, participatory activities, storage protocols and potential benefits for the individual farmers and for their communities. The project has benefited significantly from the work of a Bangladeshi researcher and UC Davis Project Scientist, Amrita Mukherjee, who has proved very effective in working with the farmers and in involving women farmers in the project.
Storage experiments:

The project plan was to compare the traditional short-term storage of potatoes in farmers' homes or outbuildings with storage in 'ambient storage' buildings designed by the Bangladesh Agricultural Research Institute (BARI), with storage in large commercial storage facilities, and with storage in small-scale coolrooms using the CoolBot/Air Conditioner system for refrigeration. Replicate samples from 6 growers in each of the four target districts were held in 10 kg mesh bags under the different storage conditions.

Weight loss in potatoes stored in household or ambient storage conditions was very high; after two months' storage, weight loss was 25% in potatoes stored in household conditions, and 15% in those stored in ambient storage. During the same period, potatoes stored in the commercial cool store lost 2% of their moisture, mostly during the first two weeks, presumably reflecting weight loss during curing and cooling. Because of the high temperatures and relative humidity in the household and ambient storages, sprouting started in the sample potatoes within one week of being placed into storage. No significant sprouting occurred in the samples held in the commercial cool stores. These data emphasize the importance of cool storage for long-term storage of potatoes.

During the year, 6 CoolBot rooms were constructed using structural insulated panels imported from India. One room, located at the local BARI station was operational by mid-year, and storage samples were transferred to it from the commercial coolstore. The remaining CoolBot stores will be operational as soon as electricity connections are provided by the Rural Electrification Board. Unfortunately Bangladesh's critical power shortage has forced the Government to discontinue new connections. A solar system was installed on one of the CoolBot rooms (in Barisal), and is currently being evaluated.

Postharvest Training for Smallholder Horticulturists in Central America

In mid-2012 the Horticulture CRSP/UC Davis received funds from the USDA Foreign Agricultural Service for a project whose primary goal is to replicate, for Central America, the very successful annual Postharvest Technology Short Course conducted at UC Davis. This course is a two-week intensive study of the biology and current technologies used for postharvest handling of fruits, nuts, vegetables, herbs and ornamentals. It is designed for research and extension workers, quality control personnel in the produce industry, and business, government or academic professionals interested in current advances in the postharvest technology of horticultural crops.

Our goal was to initiate a similar course, in Spanish, for postharvest researchers and practitioners from Central America at Zamorano, Honduras. In June 2012 a Zamorano researcher, Victor Figueroa, attended the course in Davis. Victor was an essential component of the first offering of the short course in Honduras, which took place in May 2013, in association with the Horticulture CRSP Regional Center of Innovation at Zamorano, and with the assistance of its director, Julio Lopez. The course was conducted in Spanish, and while following the outline of the UC Davis course, was structured so as to focus on the needs of smallholder farmers (particularly women) in postharvest handling and marketing of important regional crops, especially tropical fruits and vegetables.

The course provided practical technical information related to improved harvest, grading, packing, cooling, storage, cool transport and marketing of horticultural crops. It included a strong focus on food safety, including both pre-harvest Good Agricultural Practices and postharvest technologies designed to minimize chemical and microbial contamination. Substantial time was also devoted to hands-on demonstrations and participatory work.

UC Davis faculty Michael Reid and Marita Cantwell participated in the first Zamorano short course, but the majority of the course was taught by local postharvest researchers and practitioners. We felt that the course was successful, and evaluations from the 45 participants were generally very positive. Our observations included the need to increase participation by women, both as instructors and in the class.

A major challenge will be identifying sources of support that can make the class self-sustaining into the future. The fee structure that supports the UC Davis short course is not practical in Central America, and support from NGOs, government, or local agribusiness seems critical to ongoing viability of the course. Discussion at the end of the first course included a suggestion that it might be more focused on researchers, and might rotate among the universities in Central America.

The second offering, this year, also at Zamorano, will also include Dr Cantwell. Another researcher from Zamorano will attend the UC Davis short course this year.

Human and Institutional Capacity Development

Capacity building is a pillar of Horticulture CRSP projects. Since 2009, Horticulture CRSP projects have provided short-term training for 31,841 people, over half of whom are women. We have supported 117 long-term students and worked with 249 additional students in our projects. Nearly 60% of our long-term students have been women and two-thirds of students are undergraduates. We collaborated with the University of Minnesota's Humphrey School of Public Affairs and supported the efforts of five graduate students to assess legal and policy barriers faced by women in horticulture in four countries. A summary of their report is included in this annual report and the entire report can be found in Appendix 7.

In addition to student training, Horticulture CRSP is committed to building institutions. We have worked with over 100 partners throughout the world. Our projects provide critical research funding and professional development to in-country researchers and extension educators. In addition to universities and research institutions, Horticulture CRSP supports small developing country organizations through our Trellis Fund. The 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. With a focus on impact and expansion of locally proven ideas, the Trellis Fund matches the organizations with students and provides modest funds to support the organization's farmer outreach program.

Summaries of our short-term and long-term trainees for 2012-13 follow.

Short-term training

Participant nationality	Total number of participants	Males	Females	Purpose of training
Bangladesh	1	0	1	Postharvest management of fresh produce
	3	2	1	Project management
Benin	46	43	3	Disease identification
	8	7	1	Pest identification
Cambodia	85	52	33	Ambient desiccant seed drying
	15	0	15	Irrigation
	3	1	2	Postharvest management of fresh produce
	4	3	1	Project management
	120	80	40	Training on Horticulture CRSP technologies
Costa Rica	7	3	4	postharvest
Guatemala	6	6	0	Postharvest
Honduras	28	20	8	Postharvest
	1	1	0	Training on instructing a development laboratory
Hong Kong	1	1	0	Project management
India	1	1	0	Postharvest management of fresh produce
	3	3	0	Project management
Indonesia	6	3	3	Postharvest management of fresh produce
	14	10	4	Project management
Kenya	15	0	15	Compost
	16	0	16	Crop rotation and soils
	300	156	144	Irish potato production
	24	6	18	Irrigation
	29	8	21	Leadership and record keeping
	12	7	5	Packaging quality; demand for produce
	12	0	12	Planting and irrigation
	15	0	15	Postharvest cooling
	24	6	18	Postharvest handling
	24	8	16	Record keeping
	5	0	5	Safe handling of chemicals
	20	3	17	Seedling production
	7	0	7	Sowing of indigenous vegetables
	28	10	18	Tools
Laos	2	1	1	Postharvest management of fresh produce
	1	1	0	Project management
Malaysia	2	1	1	Postharvest management of fresh produce
Myanmar	2	0	2	Postharvest management of fresh produce
	2	1	1	Project management
Nepal	20	12	8	Demonstration of seed drying with zeolite beads

Participant nationality	Total number of participants	Males	Females	Purpose of training
Nepal (cont.)	23	0	23	Demonstration of seed drying with zeolite beads
	14	8	6	Demonstration of seed drying with zeolite beads
	32	26	6	Innovative technologies for smallholders
	180	90	90	Integrated Pest Management
	32	10	22	Seed drying with zeolite beads
	180	45	135	Soil fertility and organic tomato production
	32	22	10	Training on conducting demonstrations
Nicaragua	78	20	58	Biointensive agriculture, organic IPM and nutrition
Pakistan	2	2	0	Postharvest management of fresh produce
Philippines	1	1	0	Postharvest management of fresh produce
	2	1	1	Project management
Rwanda	5	1	4	Ambient desiccant seed drying
	200	0	200	Mushroom production
South Africa	1	1	0	Project management
Sri Lanka	10	10	0	Handling of horticultural produce
Taiwan	3	0	3	Project management
Tanzania	15	1	14	Candied citrus
	24	0	24	Crop handling and agribusiness management
	22	1	21	Food processing
	21	2	19	Food processing
	41	2	39	Food processing
	110	24	86	Indigenous vegetable production
	15	1	14	Jams and jellies
	28	24	4	Marketing information
	28	13	15	Packing
	14	7	7	Pectin extraction
	63	37	26	Postharvest handling
	37	20	17	Postharvest handling
	85	33	52	Postharvest handling
	17	2	15	Postharvest handling
	18	4	14	Postharvest handling
	36	10	26	Postharvest handling
	47	30	17	Postharvest principles
	16	2	14	Postharvest principles
	16	5	11	Postharvest principles
	7	4	3	Training of postharvest trainers
	22	14	8	Zero energy cooler construction
	18	16	2	Zero energy cooler construction
	8	4	4	Zero energy cooler construction
	39	18	21	Zero energy cooler construction

Participant nationality	Total number of participants	Males	Females	Purpose of training
Thailand	17	12	5	Ambient desiccant seed drying
	14	9	5	Ambient desiccant seed drying
	6	6	0	Demonstration of seed drying with zeolite beads
	32	15	17	Handling of horticultural produce
	5	2	3	Handling of horticultural produce
	46	9	37	Postharvest management of fresh produce
	3	1	2	Project management
	5	3	2	Training on Horticulture CRSP technologies
Uganda	187	62	125	Citrus and mango production
	174	68	106	Cowpeas as a horticultural crop
	11	7	4	Enumerator training
	238	76	162	Orange fleshed sweet potato production and postharvest
	126	47	79	Organic IPM for vegetables
	138	56	82	Postharvest best practices
Unknown	12	8	4	Handling of vegetables
	16	7	9	Postharvest
	16	8	8	Postharvest
Vietnam	9	6	3	Postharvest management of fresh produce
	1	0	1	Project management
	16	10	6	Training on Horticulture CRSP technologies
Zambia	39	9	30	Agricultural production
	13	0	13	Crop rotation and soils
	2	2	0	Data collection
	24	6	18	Irrigation
	24	0	24	Packaging quality; demand for produce
	2	2	0	Postharvest
	24	6	18	Postharvest handling
	35	0	35	Postharvest of indigenous vegetables
	27	0	27	Production of indigenous vegetables
	8	0	8	Sowing of indigenous vegetables
	9	0	9	Use of tools

Long-term training

Country of Origin	Sex	Degree	Discipline	University
Bangladesh	F	Ph.D.	Agricultural Systems Engineering	Asian Institute of Technology
Benin	F	Ph.D.	Plant Pathology	Montpelier University
	M	Ph.D.	Agricultural Economics	University of Abomey-Calavi
	M	M.S.	Agronomy and Crop Science	Ecole Sup. Agron. Montpellier (France)
	M	M.S.	Agricultural Economics	Université d'Abomey-Calavi
	M	M.S.	Agricultural Economics	Université d'Abomey-Calavi
	unknown	B.S.	Crop Production	EPAK (Université d'Abomey-Calavi)
	unknown	B.S.	Agricultural Economics	Ketou University
	unknown	B.S.	Agricultural Economics	Ketou University
Cambodia	F	B.S.	Agricultural Economics	Royal University of Agriculture
	M	B.S.	Unknown	Hanoi University of Agriculture
	M	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agricultural Economics	Royal University of Agriculture
	unknown	B.S.	Agronomy	Royal University of Agriculture
Cambodia	unknown	B.S.	Agricultural technology	Royal University of Agriculture
	unknown	B.S.	Agricultural technology	Royal University of Agriculture
	unknown	B.S.	Agricultural technology	Royal University of Agriculture
	unknown	B.S.	Agricultural technology	Royal University of Agriculture
	unknown	B.S.	Agricultural technology	Royal University of Agriculture
	unknown	B.S.	Agricultural technology	Royal University of Agriculture
	unknown	B.S.	Agricultural technology	Royal University of Agriculture
Chile	unknown	M.S.	International Agriculture Development	University of California, Davis
Costa Rica	F	M.S.	Agronomy	Instituto Tecnologico de Costa Rica
Ghana	M	M.S.	Unknown	University of Development Studies
Guatemala	F	M.S.	Agronomy	University de San Carlos
	M	M.S.	Agronomy	University de San Carlos
Honduras	43 F	B.A	Postharvest	Zamorano University
	108 M	B.A	Postharvest	Zamorano University
Kenya	F	M.S.	Crop Protection	Egerton University
	F	M.S.	Horticultural Science	Egerton University

Country of Origin	Sex	Degree	Discipline	University
Kenya	F	M.S.	Horticultural Science	Egerton University
	F	M.S.	Horticultural Science	Egerton University
	F	M.S.	Crop Protection	JKUAT
	F	M.S.	Crop Production	Kenya Methodist University
	F	M.S.	Crop Production	Kenyatta University
	F	M.S.	Crop Protection	Kenyatta University
	F	M.S.	Entomology	Kenyatta University
	F	M.S.	Crop Protection	Moi University
	F	M.S.	pest management	University of Eldoret
	F	M.S.	Crop Protection	University of Nairobi
	F	B.S.	Agronomy and Crop Science	Kenya University of Technology
	M	Ph.D.	Agribusiness Management	Egerton University and Auvergne University
	M	M.S.	Crop Protection	Kenyatta University
	M	M.S.	Crop Protection	Kenyatta University
	M	M.S.	nutrient and soil management	University of Eldoret
	M	M.S.	nutrient composition	University of Eldoret
	M	M.S.	Plant Pathology	University of Eldoret
	M	M.S.	seed science	University of Eldoret
	M	M.S.	Crop Protection	University of Nairobi
Nepal	F	Ph.D.	AgriBusiness Management	Asian Institute of Technology
Nicaragua	M	M.S.	Unknown	University of Wisconsin-Madison
Rwanda	M	Ph.D.	Unknown	University of California, Davis
Tanzania	M	Ph.D.	Unknown	ANGRAU, Hyderabad
	M	M.S.	nutrient composition	Sokoine University
Turkey	unknown	Ph.D.	Rural Sociology	Pennsylvania State University
Uganda	F	B.S.	Unknown	Uganda Christian University
	F	B.S.	Unknown	Uganda Christian University
	F	B.S.	Unknown	Uganda Christian University
	F	B.S.	Unknown	Uganda Christian University
	M	B.Sc.	Unknown	Uganda Christian University
unknown	F	Ph.D.	Unknown	Colorado State Univeristy
	F	Ph.D.	Unknown	Instituto Tecnologico de Costa Rica
	F	M.S.	Unknown	University of California, Davis
	F	M.S.	Unknown	Egerton University
	M	Ph.D.	Unknown	The Ohio State University
	unknown	M.S.	Unknown	Nong Lam University
USA	F	Ph.D.	Plant Pathology	Cornell University
	F	Ph.D.	Unknown	North Carolina State University
	F	Ph.D.	plant physiology	Purdue University

Country of Origin	Sex	Degree	Discipline	University
USA	F	Ph.D.	Food science, food safety	Rutgers University
	F	Ph.D.	Agricultural Economics	University of California, Davis
	F	Ph.D.	Plant Pathology	University of California, Davis
	F	Ph.D.	Unknown	University of California, Davis
	F	Ph.D.	Unknown	University of California, Davis
	F	Ph.D.	Unknown	University of California, Davis
	F	M.S.	Unknown	University of California, Davis
	F	M.S.	Unknown	North Carolina State University
	F	M.S.	Unknown	North Carolina State University
	F	M.S.	Hydrological Sciences	University of California, Davis
	F	M.S.	International Agriculture Development	University of California, Davis
	F	M.S.	International Agriculture Development	University of California, Davis
	F	M.S.	International Agriculture Development	University of California, Davis
	F	M.S.	International Agriculture Development	University of California, Davis
	F	M.S.	International Agriculture Development	University of California, Davis
	F	M.S.	International Agriculture Development	University of California, Davis
	F	M.S.	International Agriculture Development	University of California, Davis
	F	M.S.	Soil Science	University of California, Davis
	F	M.S.	Unknown	University of California, Davis
	F	M.S.	Unknown	University of California, Davis
	F	M.S.	Food Science	University of Georgia
	F	M.A.	International Agriculture Development	University of California, Davis
	F	B.S.	College of Engineering	University of California, Davis
	F	B.A.	Communications	University of California, Davis
	M	Ph.D.	Plant biology, breeding and nutrition	Rutgers University
	M	Ph.D.	Plant Breeding and Nutrition	Rutgers University
	M	Ph.D.	Agricultural Economics	University of California, Davis
	M	Ph.D.	Horticulture and Agronomy	University of California, Davis
	M	Ph.D.	Soil Science	University of California, Davis
	M	M.S.	Unknown	Cornell University
	M	M.S.	Unknown	Cornell University
	M	M.S.	Unknown	North Carolina State University
	M	M.S.	Geography	Pennsylvania State University
	M	M.S.	Int'l Ag Development	University of California, Davis

Country of Origin	Sex	Degree	Discipline	University
USA	M	M.S.	International Agriculture Development	University of California, Davis
	M	M.S.	International Agriculture Development	University of California, Davis
	M	M.S.	Unknown	University of California, Davis
	M	M.S.	Plant Pathology	University of California, Davis
	M	M.S.	Unknown	University of California, Davis
	M	M.S.	Unknown	University of California, Davis
	M	M.S.	Unknown	University of Hawaii at Manoa
	M	B.S.	College of Engineering	University of California, Davis
	M	B.S.	Computer Science	University of California, Davis
	unknown	Ph.D.	Tropical Plant and Soil Science	University of Hawaii, Manoa
	unknown	Ph.D.	Plant Pathology	University of California, Davis
	unknown	M.S.	International Agriculture Development	University of California, Davis
Vietnam	F	Ph.D.	Postharvest Physiology	University of California, Davis
	F	B.S.	Unknown	Hanoi University of Agriculture
	M	B.S.	Unknown	Hanoi University of Agriculture
	unknown	M.S.	Unknown	Hanoi University of Agriculture
	unknown	M.S.	Unknown	Nong Lam University
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
	unknown	B.S.	Unknown	Hanoi University of Agriculture
Zambia	M	B.S.	Agriculture	University of South Africa

The Trellis Fund

Project Description

The 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. With a focus on impact and expansion of locally proven ideas, the Trellis Fund matches the organizations with students and provides modest funds to support the organization's farmer outreach program.

Organizations in developing countries submit proposals for up to $2,000 in funding to conduct adaptive research and outreach on problems faced by local farmers in horticultural production, pest management, postharvest practices, nutrition or marketing fruit and vegetable crops. Graduate students from the University of California, Davis, Cornell University, North Carolina State University and Hawai'i at Mānoa apply to be part of the Trellis projects. Selected students are reimbursed for travel expenses to visit their assigned project and receive a $300 fellowship for 100 hours of additional project support via email.

Collaborators:

USA

- Carrie Tieken, Bob Johnson, Whitney Brim-deForest, AJ Campbell, Graham Savio, Ephrem Rukundo, and Sarah Sahlaney, UC Davis
- Bryan Sobel and Brian Flanagan, Cornell University
- Rachel Suits, Arun Jani, Amanda McWhirt, and Angel Cruz, North Carolina State University
- Gabe Sachter-Smith, University of Hawai'i Manoa

Uganda:

- Stephen Ssemakula, Uganda Environmental Education Foundation
- Dr. Charles Kajura, Eco-Agric Uganda
- Robert Amayo, NaSARRI/NARO
- Okalo Paul, Teso Women Development Enterprise
- Sam Mwebe, RASD
- Dr. Archileo Kaaya, UNCE

Rwanda:

- Alphonse Karenzi and Maurie Mugabowindewe, Sustaining Rwanda Youth Organization
- Julie Carney, Gardens for Health International

Kenya:

- Jackson Sambu, Eldoret Region Company – Christian Community Services

Nepal:

- Basanta Rana Bhat, ECOCENTRE
- Sabitri Dahal, SADP-Nepal

Tanzania:
- Dr. Severine Assenga, Sapporo Mobi-Vet

Honduras:
- Susan Paola Gomez Ramos, Axel David Gonzalez Murillo, Promesa

Nicaragua:
- Pablo Diaz Hernandez, Caritas Parroquial Esquipulas

Key Accomplishments:
- 106 demonstration plots constructed
- More than 60 farmer trainings held, attended by 1930 farmers (65% women)
- 12 US graduate students visited their partner organizations in Feed the Future countries
- 1 nursery and 1 community agriculture school established
- High rates of adoption of new technologies as a result of the projects
- Participating graduate students attended 6 practical trainings
- 62 developing world graduate students engaged by Trellis projects

Technical Narrative:
In Spring 2012, Horticulture CRSP issued a Request for Proposals for the second round of the Trellis Fund. Applications were accepted from universities, NGOs, and research organizations in Feed the Future Countries. As in round one, $2000 grants were available for small-scale horticulture-focused projects. We contacted more than 754 organizations directly, and also spread the word through the Horticulture CRSP website, list-serv and other related list-servs. As a result of these efforts, we received 42 unique applications from 14 countries.

Based on lessons learned from the first round of Trellis, we made several changes graduate student eligibility and requirements. Firstly, we opened Trellis to applications from students from North Carolina State University, the University of Hawaii-Manoa, and Cornell University. These universities partner with the Horticulture CRSP ME, and Trellis provided a way to engage their students with Horticulture CRSP. In addition, we required graduate students to travel to their partner organizations this year. According to both students and organizations, the most successful projects in round one of Trellis were the projects where the student visited the organization. In addition, we found that organizations were much more responsive to their students after they met the student in person. This year, students were offered the cost of travel and lodging for their visit to their organization, as well as a $300 stipend upon the successful completion of the project. We received 38 applications from graduate students from all four partner schools. 14 students (4 from NCSU, 2 from Cornell, and 1 from University of Hawaii-Manoa) were selected.

In August, 2012, Horticulture CRSP funded 14 Trellis projects. For an investment of approximately $60,000, Horticulture CRSP funded:
- 106 demonstration plots
- Over 60 farmer trainings, which reached 1930 farmers (65% women).
- 12 graduate student visits to organizations – 2 of the students involved were first time international travelers

In addition:

- 3 projects used farmer field schools
- 5 used “training of trainers” techniques
- 2 farmer field trips were held
- 1 nursery was established
- 1 permanent “community agriculture school” was established
- Projects used ICT to communicate with farmers: 10 used cell phones, 2 used radio, and 2 used internet or email

Horticulture CRSP engaged:

- 14 research organizations and NGOs
- 14 US graduate students
- 62 developing world students

According to the participating organizations, 1602 (1087 women) adopted new practices as a result of these projects. This 83% adoption rate far exceeds the 10% goal adoption rate. Although these reported rates are high, this may be partially accounted for by the fact that local agronomists are in a good position to identify the improved varieties and production practices that are best suited to their surrounding farmers. Projects also reported that participants were introducing neighbors to new practices, and so adoption spread beyond those trained by the projects. According to Teso Women Development Organization (Uganda), “This project has opened people’s minds and changed people’s perceptions ...Many beneficiaries thought that a mango or citrus tree with more branches will produce more fruits and that pruning trees is being destructive equating it to wastage. Most small scale fruit farmers now consider tree pruning vital activity that increases citrus and mango yields and contributes to the reduction of pests and diseases”.

In addition, Trellis provided 6 trainings to participating graduate students. Topics included diagnosing problems in the field, gender and culture, working with farmer field schools, and careers in international development. Discussions were lively, and students were engaged. However, the participation of students from the three other schools made meetings more logistically difficult, both due to coordinating multiple time zones and arranging for people to connect to meetings via phone and internet. Overall, the training sessions went well, and students from the other universities contributed to discussions. For Trellis round 3, we will continue to think about how to improve trainings for non-UC Davis students.

Going into year three, we are making a concentrated effort to evaluate the program and respond to data in the student and organizational reports. As this was the first year that all students traveled, we will evaluate and refine Trellis based on their experiences working directly with their organizations. Overall, student response to Trellis was very positive. 10 of the 12 students who completed the exit survey said that they plan to pursue an informal relationship with their organization, and 3 said that they were collaborating on a specific project with their partner organization. All student respondents said that we should do Trellis again next year.

The projects also gave positive feedback about working with Trellis and the graduate students. Several organizations identified the graduate student’s visit as the best part of Trellis. According to SADP (Nepal), “The best part was the communication with the US graduate as they suggest[ed] innovative technologies with a lot of information and they helped a lot in making the project successful". The major change suggested by organizations was that Trellis increase funding to more than $2000 (suggested by 8 out of 12 organizations). In addition, 4 organizations suggested that graduate students stay for a longer time.

Capacity Building

- 14 US graduate students gained experience working in international development. They also received practical training through monthly Trellis trainings.
- 62 developing country students (undergraduate and graduate) were involved in Trellis projects in their home countries.
- 60 farmer trainings held by Trellis organizations, working in partnership with their US graduate student
- Organizations built capacity in managing US-based grants and the accompanying paperwork
- One community nursery established
- One community agriculture school established

Lessons Learned

We have found that Trellis is most successful when we work with small-scale organizations. Since it is such a small grant, it seems that large organizations tend to be less invested in their Trellis projects. For the next round, we need to figure out a way to filter out large organizations.

We also need to either allow much more time for the contracts to go through on the Davis end, or figure out a way to do our side of the contracts faster. This was a problem in round 2, and unfortunately an even bigger problem in round 3 – to the point that several projects were delayed.

Technology transfer and scaling partnerships

Horticulture CRSP has several promising technologies to scale. In 2012-12, 58 new technologies were under research, 59 are under field evaluation, and 73 were made available for transfer. In the past four years, we have worked transferred technologies to over 600 organizations and our project partners have formed 140 public-private partnerships.

Scientists from the US and Developing Country institutions are developing and adapting a range of innovative technologies aimed at significantly improving the profitability of horticultural production in Africa and other parts of the world. Current studies include low-cost cold storage and transportation systems, portable and reusable drying beads for seeds and other dried products, improved solar drying technologies, cell-phone extension services, barrier nets that reduce the need for pesticides and create a microclimate for row crops, and high tunnels to mitigate climate challenges and extend production and marketing seasons. The goal is to test 'disruptive' technologies that can overcome developing country constraints of small farm size, limited capital, and poor infrastructure. Our researchers are exploring innovative uses of modern materials and technologies to overcome the challenges of production and marketing of horticultural crops. Among the technologies that we are exploring for future are opportunities for innovative uses of energy (including photovoltaics) for overcoming barriers that limit the participation of smallholder farmers in the horticultural value chain. Horticulture CRSP is establishing Centers of Innovation in collaboration with leading research institutions around the world, where these technologies can be deployed, adapted to local conditions, tested on smallholder farms and extended to local stakeholders.

Given the complexity of horticulture, innovative "leapfrog" technologies can reduce constraints and input costs that limit the ability of smallholder farmers to achieve maximum profitability in the production and marketing of high-value horticulture products. The Horticulture CRSP projects have researched and adapted proven technologies and have come up with a number of new and novel leapfrog technologies and innovations that will reduce poverty and hunger.

The work of innovation in horticulture is to make something better, more efficient, more nutritious, more productive or more profitable. The Horticulture CRSP believes that specific technologies and innovations have the ability to solve problems and challenges and 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 Lab focuses on technologies that reduce on-farm costs, use labor more efficiently, empower women, build partnerships, and sustainably use natural resources.

We know that often the simpler a technology is, the more likely its up-take and adaption to local conditions will be. Access to materials, final cost, and actual and perceived benefits all play an important role in farmer adoption. Our research addresses all of these aspects of technology design and dissemination.

The Horticulture CRSP's technology toolbox" is a selection of tested and proven technologies including those that have been developed and/or demonstrated in Horticulture CRSP projects. Currently Horticulture CRSP scientists are adapting a range of innovative technologies aimed at significantly improving the profitability of horticultural production for smallholder farmers.

Through the Horticulture CRSP Regional Centers of Innovation, these technologies will be deployed, adapted to local conditions, tested on farms and extended to local stakeholders. Each of the centers will add local innovations to the toolbox and will continue to research and adapt these technologies for local use while following rigorous research methods and community participation. The technology toolbox is located in Appendix 9.

In addition to the technologies in the toolbox, our projects are developing other methodologies which will be ready for scale. These include “soft” technologies such as techniques for farmer education and farmer savings.

Governance and Management Entity Activity

Horticulture CRSP has adapted a Mitzberg model as a method to understand our organization and governance.

The model is based on the following areas:
Guiding Principles:
The guiding principles are the halo of beliefs, traditions, norms, values and culture of the organization. Guiding principles for the Horticulture CRSP are embodied in the mission statement: "We build international partnerships for fruit and vegetable research to improve livelihoods in developing countries." Through partnerships and research efforts, we aim to improve livelihoods through higher profits and diversified, nutrient-rich diets.

In addition to the overarching general principles, there are three needs in horticulture to which the organization is dedicated: Increased research capacity, technological innovation, gender equity, and improved access to information.

Strategic Apex: Directorate:
The strategic apex is charged with ensuring that the organization serves its mission in an effective way. It plans strategic directions, defines general priorities, sets agendas, initiates processes and systems to accomplish the priorities, allocates resources, convenes meetings planning sessions and workshops, adjusts directions based on advice and evaluations from the members and the techno-structure, and mobilizes partners and additional resources.

The strategic apex is composed of the Horticulture CRSP Director; the International Advisory Board; the Chancellor; the College of Agriculture and Environmental Sciences' Dean and Associate Dean for International Programs; and the Chair of the Department of Plant Sciences of the University of California, Davis; USAID through its policies and Agreement Officer Representative (AORs); the External Evaluation Team; and technical support staff to the Director.

External factors that influence Apex decisions are:

- Research capability: ability to conduct successful research within the priorities;
- Social: ability to deliver research and extension within the socioeconomic priorities;
- Administrative/Political: ability to select the correct mix of domestic and international partners within requirements and recommendations of the donors and partners.

Operations Management:
Operations Management joins the strategic apex to the operating core by the use of delegated formal authority. Operations management ensures horizontal and vertical integration. With respect to horizontal integration, this unit coordinates between and within operational units i.e., program and support management. With respect to vertical integration, this unit ensures congruence between the operating core programs and the guiding principles of the Horticulture CRSP, and top-down/bottom up transfer of information. This unit controls peripheral decisions, and interprets and adapts national guidelines to project conditions and operations.

Support Management:
Support Management is composed of specialized units that exist to provide support to the organization outside the operating work flow. In the model, the Support Management unit provides logistical backup such as accounting, financial management and human resources.

In the case of the Horticulture CRSP, the University provides its full array of support functions including: financial management, information systems, computer support, personnel, funding and management of awards and sub-awards, travel and sponsored programs.

Program Management & Collaborative Research Activities:
Program management consists of the analysts who serve the organization by affecting the work of others. Our activities consist of projects and initiatives that span the horticultural value chain while addressing our guiding themes

In addition to this structure, it should be noted that there is significant informal and formal communication, and team formation that crosses the flexible boundaries across the units. For example, teams were formed to review the project proposals submitted for the various Requests for Proposals. Members of these teams included advisory board members, directors, operations management personnel, and representatives from the support function units. On a day-to-day basis, there is a constant connection between and among the units.

Regional centers of innovation

In collaboration with partner institutions, the Horticulture Innovation Lab Regional Centers will serve the regions of East Africa, Central America and Southeast Asia to showcase technologies and innovations that can improve horticulture in their respective regions. The Central America center is located at The Panamerican Agricultural School, Zamorano, Honduras, the East Africa center is at the Practical Training Center with the Kenya Agricultural Research Institute (KARI) in Thika, Kenya and the Southeast Asia center is at Kasetsart University in Bangkok, Thailand.

The centers connect horticultural researchers, extension workers, farmers, non-governmental organizations (NGOs) and relevant private sector partners within their respective regions. The centers each 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 centers work with national agriculture research and extension systems, agricultural universities, NGOs and the private sector to provide ongoing training for the local horticultural industry and for trainers both at the centers and across the region. The centers draw on local experts who have received technical training through advanced degree programs or train-the-trainer courses. The centers provide testing grounds for horticultural technologies and physical facilities for workshops and training sessions. Each center houses a number of horticulture technologies that have been researched and validated by Horticulture Innovation Lab researchers and in country partners. The most suited technologies are on display and used for trainings and research.

Key accomplishments FY13

2012-2013 has been a year of growth for the Horticulture CRSP regional centers, our final center opened in Kenya and our other two centers have had a year full of trainings and research activities. The center in Honduras has built a wonderful facility with space for lectures, net houses for pest control, solar pumping and irrigation, testing new alternative crops, and integrating students into all aspects of the Center. In Thailand faculty have been researching and testing materials to insulate a low cost cold room, as well as testing affordable ways to convert a household AC unit into a powerful cooler. Our partners and researcher investigating the drying beads continue to work to expand their network and sales. The AgLearn project started with training in Nepal and will have additional trainings in 2014 in Bangladesh, and Cambodia. The center in Thailand continues to have a strong relationship with AVRDC, including having its Regional Director on their steering committee.

Honduras

The Center for Innovation was inaugurated in September 2012 as an initiative to help farmers in producing vegetables and fruit to be more competitive and sustainable. The center facilities have been donated to this project by Zamorano University and a number of technologies have been set up and are either undergoing testing or are being used to train farmers and students. The center has been successful in establishing postharvest technologies, integrating Zamorano students into the daily activities of the center and hosting visits from a number of private companies, NGOS and other academic institutions.

- Student training and Module. The site of the center is home to a rotating group of students who are taught and trained in vegetable production, technology and agronomy. Students get credit and time to work on their individual research plots which are also a part of the center. This course is integrated with a USAID funded climate change adaption project also implemented by Zamorano.

- The center houses 4 protective structures, to mesh houses, 1 large macro tunnel and 1 smaller micro tunnel. These are used for the production of high value solanaceous crops. The center has found that these structures are a viable technology for medium sized producers. These farmers have a difficult time producing these crops in open fields due the many pests present.
- Installation of soil and water conserving methods of vegetable production using live barriers.
- Research on Aloe Vera and Jamaica Rose as alternative crops for small farmers.
- Permaculture garden with medicinal herbs build by students.
- Research plot of taro root to test and demonstrate feasibility on water logged soils, and as an alternative crop. The Innovation Center will have this crop for teaching and showing farmers and student how to cultivate this and how to process the root to be ready for the market.
- Visits:
    - University of Colombia
    - CEFEDH
    - USAID CCRD project growers
    - Georgetown University seed program
    - North Carolina State University
    - Horticulture CRSP
    - Kansas State University
    - Walmart Hortifruti
- Trainings
    - May 2013 postharvest training course (23 men and 10 women from Central America)
    - Students trained 163 senior student from Zamorano, (112 men and 51 women)
    - CCRD-USAID trainings on climate change adaption

Thailand

The Regional Center at Kasetsart University spans the entire university involving faculty from departments such as, Food science, Agronomy, Horticulture and Agriculture Engineering. A number of the Horticulture CRSP technologies are set up across campus. Faculty and students are actively engaged in research and design modifications to these and other technologies. This center is working closely with The World Vegetable Center (AVRDC) to implement training activities.

- Over 400 guests (over half were local students) attended the "drying beads showcase" which garnered a number of press mentions and was attended by HRH Princess of Thailand.
- Food security summer school, with a postharvest training component training 75 students.
- Training on technologies in Cambodia with RUA and Cary Trexler (Horticulture CRSP PI) training 60 participants in postharvest handling and best practices, and Horticulture CRSP technologies.
- AgLearn project funded by USAID and implemented by the Asia Institute of Technology. The Regional Center trained 32 professionals in Nepal.
- 2012 AVRDC training with 38 participants from all over SE Asia.

Kenya

The Regional Center at KARI was inaugurated in May of 2012 with attendees from the US Government, USAID, KARI, the Ministry of Agriculture, FPEAK, and other local and international organizations.

- In consultation with Postharvest experts a solar dryer was built on the grounds of FPEAK.
- One postharvest training was conducted with instruction by a graduate of the Horticulture CRSP supported postharvest training in Tanzania.

Capacity Building

- In Honduras 111 male and 49 female undergraduate students went through training and "learning by doing" activities at the center.
- 75 students and faculty from Malaysia, Vietnam, Cambodia, Philippines, Thailand, Laos, Bangladesh, Indonesia have been trained by the Center in Thailand.
- Center faculty, and staff have all gained valuable experience and developed new expertise through working with the Horticulture technologies and PIs in their regionals.

Lessons Learned

- Strong and dedicated leadership is necessary for a Center to thrive.
- A supportive staff able to execute the Directors visions is absolutely necessary to a centers' success.
- Building relationships across countries will strengthen the regional networks.
- Aligning goals and priorities (as able) with local USAID Missions helps to get their buy-in.
- Searching for external funding sources helps to build the sustainability of each center.
- Involving students in research and implementation enriches our projects.
- Visits and hands on support from the Horticulture CRSP Centers Specialists increases the likelihood of success.
- Attending regional meeting, conferences and high-level workshops helps to increase the visibility and viability of each center.

Information access and dissemination

The goal of the Horticulture CRSP information management program is to strengthen the capacity of intermediaries to better deliver credible, relevant information to help horticultural producers. To do this, we undertake studies to better understand and thus identify ways to improve information access. The information management team seeks synergies across multiple projects (both within and beyond Horticulture CRSP) to collate good practices for information management. As such, the group has interacted with a large number of groups within Horticulture CRSP and beyond - working with projects involving extension, ICT in extension and information access in a number of countries. Project interactions have included: e-Afghan Ag, Afghan Agricultural Extension Project (AAEP), Modernizing Extension Advisory Services (MEAS), e-China Apple, and e-Pak Ag. Partner interactions have included Kasetsart University (Thailand), World Vegetable (AVRDC in SE Asia), the Cambodian Agricultural Research and Development Institute (CARDI), the Royal University of Agriculture (Cambodia), the Bangladesh Institute of ICT in Development (BIID).

One of the outputs of this extensive collaboration has been the refining of more than 40 fact sheets on various aspects of Extension. These fact sheets will be made available through Hort CRSP in 2014. Further, the work has been associated with the development of the "ASK ME" extension framework - a simple, easy to remember acronym highlighting key steps in a needs-driven and audience-focused extension program. Developed by Mark Bell, "ASK ME" highlights:

A = Audience and needs
S = Solutions
K = Key message
M = Message form and delivery
E = Evaluation.

"ASK ME"

1. Audience and needs
   a. Who are they? What do they need and want?
2. Solutions
   a. What is practical and relevant to meet the needs?
3. Identify core message
   a. What do people need to know to make the change?
4. Message development and delivery
   a. How can the message best be packaged and delivered?
5. Evaluation
   a. How can each step be improved?

In addition to the "ASK ME" framework, Mark Bell developed the acronym "TIGRS" to highlight the factors required for successful message delivery and adoption. These factors have been distilled from discussions across more than a dozen meetings in different countries involving both national and international information delivery agents working in traditional extension as well as those disseminating information through radio, TV, video, the internet and cell phones. "TIGRS" is an easy way for people to remember the major factors identified as important in extension.

"TIGRS":

Trust: in the message and messenger
Integrated approach: Engage farmers
Good: Practical, Demand-driven, Clear benefit (with market), Easily tested
Recommendations
Seeing is believing

The idea for "ASK ME" and "TIGRS" came from the 2013 Hort CRSP annual meeting in Nairobi, Kenya, where it clearly emerged that PIs wanted an "impact checklist" to help them and their partners disseminate information effectively. Mark Bell is in the process of developing a manual that PIs can use, and the "ASK ME" and "TIGRS" acronyms provide an easy way for people to recall the key steps.

In addition to the factors identified in "ASK ME" and "TIGRS", discussions and meetings with projects and stakeholders involved in agricultural information dissemination also emphasized the need for a local project driver: a local player (or set of players) who believe strongly in the project ideals and so are committed to guiding, directing and pushing activities on site.

Other developments in Information Management:

The potential role of the input suppliers in information delivery continues to garner attention. Some are or have been a little wary due the potential self-interest of the input suppliers (i.e., bad advice to make a sale). However, on a 2013 trip to Bangladesh, the government extension workers in a number of villages spoke to the potential role of input suppliers as a positive source of information. In one village, the extension officer indicated he sees 5-10 farmers per day. By contrast there were some 6-10 input suppliers in the village and each one provides inputs (and typically advice on pests, diseases and fertilizer, which are among the top areas of interest for farmers) to 50-60 farmers per day. The extension officer was not at all threatened by this - but rather recognized the input suppliers as an important part of the information delivery chain. Thus, we must increasingly think about using ICT and other channels to get credible, relevant content to the input suppliers. I had similar observations of the input suppliers from my last trip to Cambodia, where government extension is less developed.

Future Directions

The Horticulture CRSP annual meeting provides a valuable chance for PIs to share what they have learned about information management and dissemination across projects. It is also an opportunity for the Horticulture CRSP information management team to share their knowledge with PIs, as well as learn from the PIs' experiences. Feedback from the 2013 annual meeting contributed to the creation of the "ASK ME" and "TIGRS" acronyms.

At future annual meetings, we may want to consider holding an official workshop about extension and information dissemination principles. In addition, there is an on-going effort to make the various project extension and training materials (developed by each sub project) more widely available. There is also a need to make the various extension fact sheets available through Horticulture CRSP.

Gender policy and legal analysis of horticulture

This year, we worked with the University of Minnesota to produce a policy analysis document regarding the barriers faced by women who grow horticultural crops in Guatemala, Nepal, Tanzania, and Zambia. The executive summary is below and the entire report is in Appendix 7.

Executive Summary

In 2009 the Horticulture Collaborative Research Support Program (CRSP) at the University of California, Davis was established as part of an effort to reduce rural poverty and chronic malnutrition. Horticulture production provides individuals and families with the opportunity to better their social and economic circumstances through income generation and improved nutrition and health. However, in both agriculture and horticulture women in many developing countries earn lower wages and have access to fewer resources compared to men, despite the fact that women provide much of the labor in these sectors. To support the work of the Horticulture CRSP this report identifies barriers that have the potential to limit the benefits of horticulture production for rural women in four countries: Guatemala, Nepal, Tanzania, and Zambia. This report is divided into two components: a general overview covering broad findings and offering recommendations, and country specific analyses that offer more targeted research and recommendations for each of the study countries.

Research, including a literature review of global trends and country case studies, revealed efforts in all four countries to increase female representation in government, education, and civil society; improve the availability of skills-based training for women engaged in food production; address the complicated issue of land tenure and women's right to property ownership; and extend access to credit and other financial services to rural women. Despite these efforts gender disparity persists in all four countries studied. The key findings are as follows:

Female Representation

In each of the four study countries women continue to be underrepresented in critical areas of society. Few women are elected to government positions. Quotas may serve to increase the number of women in government but do not ensure that women appointed to reserved seats accurately represent the views of rural and low-income women or that female officials play an active role in decision-making. While countries have made progress in closing the gender gap in primary school enrollment, females lag behind their male counterparts in secondary and tertiary education enrollment. Lower literacy rates and levels of formal education may preclude women taking on leadership roles in their communities.

Skills-Based Training

Extension services provide producers with education and assistance that allows them to increase yields, improve produce quality, identify markets, and boost income. Access to extension services and other skill-based training is limited for many rural women. Barriers inhibiting women's equal participation include geographic location, time and mobility constraints, relevance of content, and the predominance of male extension officers.

Land Tenure and Inheritance

Even where laws affirm women's rights to land ownership their access to land may be hindered by other factors. Cultural traditions, societal norms, history, religion, and customary law influence land inheritance producing complex webs of regulation and practice.

Access to Credit and Financial Services

The financial services offered by commercial banks often remain out of reach for rural women. These women face challenges in obtaining credit because of geographic location, poor infrastructure, low financial literacy, and lack of sufficient collateral. Microfinance institutions are growing in number but have made only moderate progress in improving financial inclusion.

Recommendations

The consultant team used the above findings along with country-specific analyses to develop a set of recommendations designed to address chronic barriers facing women in horticulture. Since some recommendations address more than one barrier or are nuanced subsets of existing barriers, the recommendations are divided into five categories that differ slightly from those presented in the findings section of the report.

Legal Information and Services

- Promote greater awareness of legal rights to ensure that women have sufficient information to enable them to make informed decisions.
- Improve availability of legal services by establishing clinics or other mechanisms for providing legal advice and representation that could help women challenge discriminatory practices.

Training and Technology

- Bolster existing extension services and work to target training and assistance to women to ensure that women have equal access to the benefits of extension education.
- Use extension to help women access higher stages of the value chain where more value is added and the potential gains are great.
- Increase the number of female extension officers to facilitate improved information sharing with female producers.
- Expand and replicate successful Farmer Field School models that harness local farmer knowledge and encourage collaboration.
- Pursue research to identify best practices for better engaging women in skills-based training for horticulture production that could be used to inform future programming decisions.
- Include low maintenance requirements and adequate instruction in the introduction of labor-saving tools and technology.

Organizations and Cooperatives

- Support women's farmers' organizations and cooperatives that expand opportunities for rural women to better operations and participate in markets.
- Build the capacity of women's civil society organizations and facilitate connections among these groups to strengthen their ability to influence public policy.

Financial Services

- Expand financial literacy training through programs explicitly aimed at women to support greater financial inclusion and the success of female entrepreneurs.
- Build the organizational capacity of financial cooperatives to increase the chance of long-term sustainability through appropriate risk management.

Market Access

- Develop value chain analyses to understand local potential for value-added horticultural products.
- Encourage the establishment of mutually-beneficial direct contracts between companies and women-led producer groups.
- Promote the use of equitable out-grower schemes that offer unique opportunities for smallholder market engagement.
- Cultivate buying agreements with local supermarkets, an intermediary market opportunity with greater security but less stringent standards than those demanded of exports.
- A better understanding of the barriers that prevent women from fully realizing the benefits of horticulture production will assist Horticulture CRSP in pursuing strategies aimed at furthering its mission.

Future Directions

Relationship Building

The Director and Associate Director of Horticulture CRSP will continue to participate in activities of partner organizations to foster collaboration and to enhance the visibility of the Horticulture CRSP program. The Director attended the 40th Anniversary of The World Vegetable Center in October, toured their facilities and met many of their partners. Director Mitcham has been invited to speak at the As a member of the board of the Global Horticulture Initiative (GHI), Director Mitcham will attend the biannual GHI board meeting in Belgium on January 14 and 15, 2014. In late February or early March, Director Mitcham and Associate Director Crump will participate in the All Innovation Lab meeting in Nepal with the Bureau of Food Security and Regional Missions. If this meeting is canceled, we still plan to visit Nepal to meet with the Mission and other partners. Associate Director Crump will participate in the Association for International Agriculture and Rural Development annual meeting as the Secretary and Treasurer, June 2-6 in Washington DC. The management entity has agreed to collaborate with The World Vegetable Center to organize an activity in association with the ISHS International Horticulture Congress in Australia August 17-22, 2014, and Director Mitcham and Associate Director Crump will attend and participate. The Horticulture Innovation Lab Regional Center in Thailand will coordinate a second workshop at the meeting. We expect to make an additional two trips each to Africa, Latin America and Asia during this period.

Centers

The management entity has now opened three regional centers. The Center in Kenya at the Practical Training Center, hosted by KARI and FPEAK, is officially launched but has made no progress on establishing technologies or planning trainings. If the center becomes active, Center Specialist Britta Hansen will be traveling to Kenya in January to assist with technology development and planning for trainings. One additional trip by Britta to support Center activities in Kenya is possible in 2014.

The Center at Zamorano has been very active. Britta will be traveling to Honduras in December 2013 for a training activity at the center, and to Guatemala in April 2014 for additional training activities associated with the Zamorano Center. The Center will host a second Postharvest Short Course in the spring, similar to the one held in 2013 but with less instructors from the U.S. Our first Regional Center of Innovation at Kasetsart University in Thailand will also be hosting several events this year. The first is the inaugural meeting of the center's Steering Committee in November 2013. In addition, the center will collaborate on AVRDC's vegetable training and food security conference at Kasetsart University and Britta Hansen and Mark Bell will participate.

Communications

With leadership from our Communications Specialist, Brenda Dawson, we will be transitioning to our new name, Feed the Future Innovation Lab for Collaborative Research on Horticulture (Horticulture Innovation Lab). This will require changes to our website, brochure and informational materials. We are developing a blog to share information about our program and related issues. This will eventually feed into a regular newsletter. We will continue to maintain and improve our website for ease of information accessibility, and will take every opportunity to place positive stories related to our program in the Feed the Future newsletter, on the USAID webpages, and in other publications related to development and horticulture. Our Annual report for 2012-13 will be completed in December 2013. We will be producing and distributing the final report of the horticulture assessment in Central America and the ME is collaborating with Global Hort on a couple publications related to horticulture development.

Management Entity Projects

Horticulture Assessment funded by Bureau of Latin America and the Caribbean

We have been working on the report for this activity since April 2013. With additional feedback from the Mission in Honduras, we are planning one final revision of the report to be completed by the end of November. At that time we will post the report in English on our website and contract the translation into Spanish. This will also be posted. We will also prepare an Executive Summary Brochure to highlight the findings. The follow-on irrigation project in Honduras and Guatemala will be managed by Manny Reyes of North Carolina A&T. He just returned from a visit to the region and we expect the proposal from him by the end of November. This project will go through December 2014.

Potato Storage Technologies for Bangladesh funded by CIP

Some of the storage rooms have been built and potatoes are being stored. Unfortunately, they were not able to be stored under the improved technologies until several weeks after harvest. Amrita is gathering data on the storage facilities and potato quality. Unfortunately, there was a bumper crop of potatoes this year and the price is very low, even for successfully stored potatoes. We plan to collaborate with AVRDC in Bangladesh to store vegetable crops in the facilities during the time when potatoes are no longer in storage. This work will continue for the coming potato season.

RFPs and New Projects

While most of our project funds have been allocated, there are a few new activities planned for 2013-14. We will be funding one additional Trellis project in Mali that was previously suspended due to the crisis in Mali. In addition to Trellis, we will be hiring two graduate students, one with an education background and one in computer science, to work with the ME on the postharvest project with the University of Florida. The ME will take the content developed by the University of Florida team and create single source, packaged training materials. Due to a delay in our plans, the donor of the award prize for our Refrigeration Challenge backed out. We are working to secure a new donor and expect to release the RFP for this competition in 2014. Applicants will compete for the chance to build their award-winning refrigeration design at UCDavis. Designs must be affordable and feasible for developing country conditions. We plan to design a small postharvest research project to compare postharvest technologies including several designs of solar dryers and the Zero Energy Evaporative Cooler in several climatic zones. We will enlist several of the e-learners from the Barrett postharvest project to run this activity. We also plan to send out the RFP for our next set of proposals in the new five year award in late winter 2014 and award planning grants to the PIs for initial project startup activities. This will allow the projects to start more quickly after the new awards are made.

Internal Evaluation of Projects

The initial one-year projects (Immediate Impact and Exploratory Projects) have been completed for over one year. In 2013-14, we will be conducting in-depth internal evaluation of these projects to determine (1) the extent to which the projects achieved their objectives, (2) the extent to which the projects impact horticulture worldwide, (3) lasting impact of the projects, and (4) to make recommendations to the Horticulture Innovation Lab management team regarding next steps. Associate director Amanda Crump and external evaluator Paul Marcotte will travel to the following project locations to conduct evaluations (note that we will do desk reviews of projects that were located in non-Feed the Future countries):

- November and December 2013 – Cambodia, Thailand, and Sri Lanka
- March 2014 – Honduras and Guatemala
- April or May 2014 – Uganda, Kenya, and Malawi

To save money and time, these trips will be combined with other travel when possible.

Writing Plan for New Five Year Award (2014-2019)

The management entity will be busy developing the program for the next five year award beginning early in 2014. We hope to release an RFP for new proposals in late winter and award planning grants to the recipients to allow them to visit the Missions and meet collaborators to plan for their activities ahead of the project start in fall 2014.

Appendix 1
Technical Reports

Horticulture CRSP project technical reports
Theme: Seed systems and germplasm
Project 1: Seed Systems – Improving Seed Quality for Smallholders in Nepal, Bangladesh, Kenya, Tanzania, Uganda, and Rwanda led by Kent Bradford of University of California, Davis
Project 2: Semillas de Esperanza: Vegetable Seeds for Sustainable Agriculture in El Salvador, Guatemala, Honduras, and Nicaragua led by James Nienhuis of University of Wisconsin-Madison

Project Name: Improving Seed Quality for Smallholders

Project Description

High quality seeds of improved varieties are essential to enhance the production of annual horticultural crops. In tropical climates, high temperatures and humidities combine to cause rapid deterioration of seeds in open storage, resulting in loss of value, poor stand establishment, lower productivity and disincentive to invest in improved seeds. Most horticultural seeds in the targeted locations are locally produced or self-saved and are stored without facilities for drying them to moisture contents that would greatly extend their storage lives. We propose to demonstrate a simple, inexpensive and widely adaptable method for drying horticultural seeds and maintaining high seed quality during storage. A novel zeolite desiccant, combined with inexpensive hermetic containers, can both dry horticultural seeds and maintain them in a dry state during storage, greatly increasing their storage lifetime. As women perform most of the seed production, harvesting and storage operations for horticultural seeds in these regions, adoption of this system would have direct benefits by enhancing the value of their labor. This simple seed drying and storage system would enable the development and distribution of more productive varieties, marketing of higher quality products and increases in women's and families' incomes.

Collaborators:

US

- Kent J. Bradford, Principal Investigator, University of California, Davis

Nepal

- Luke Colavito, International Development Enterprises (iDE)
- Jwala Bajracharya, Nepal Agricultural Research Council (NARC)
- Indra Raj Pandey, Center for Agricultural Policy Research, Extension and Development (CEAPRED)

Kenya

- Roger Day, CABI Africa (Centre for Agricultural Bioscience International)

India

- Keshavulu Kunusoth, Acharya N G Ranga Agricultural University

Thailand

- Johan Van Asbrouck, Rhino Research
- Ganesh Shivakoti, Asian Institute of Technology (AIT)

Key Accomplishments:

- The project's key accomplishment this year was formulating and disseminating the concept of the "dry chain" to encompass the entire process of drying, packaging and storing dry commodities. This concept is a success because it is conceptually easy for stakeholders to understand and remember. It will be crucial that the project develop the dry chain in the coming months.
- Another success is the project's shift in emphasis to encourage capturing dry environmental conditions with hermetic packaging when possible and using drying beads to further dry seeds and commodities when required.

Technical Narrative:

Dr. Bradford attended the Annual Horticulture CRSP meeting at Nairobi, Kenya and travelled to Nepal, Thailand and China thereafter. Key trends emerging from those meetings include:

- Early seed and plant vigor is very important to smallholder farmers. The project has determined that vigor will also be higher in bead-stored seeds. It will be important to document the effect of drying in seed tests or particularly in field emergence rather than at later stages of plant growth.
- It is crucial that the project find a better way to reactivate the beads without electricity. In addition to the "DryBot" for a dry air supply, the "chimney" system could be suitable for drying a batch of drying beads at a time over a heat source.
- Rhino Research has developed the "DryBox" and "DrumDry," which can be used to dry and store seeds under almost optimal moisture content conditions. This unit not only keeps the seeds sealed, but also can alert the seed managers by a 'Color/Sign' warning when the environment inside the container is unsafe. The "DryBot" enables continuous generation of dry air suitable for drying larger quantities of seeds or commodities and would not require manual transfer of the beads to an oven for reactivation.
- A key next step is to determine how to scale up the drying and match it with packaging to initiate the dry chain with the seed growers themselves. Simultaneously, work needs to be done with the companies to which growers sell in order for the companies to understand how to keep the seeds dry.
- The project also must promote the dry chain concept and engage with manufacturers or distributors of waterproof packaging to explore how to preserve dryness throughout the seed system. Our focus for the remainder of the project should be to satisfactorily complete the data collection on the experiments in progress while expanding our communication and liaison efforts with actors in the value chain to incorporate and implement the dry chain concept.
- Discussions with a number of partners indicated that extension efforts must highlight that beads must be used repeatedly in order to achieve the economic benefits. A simple demonstration of how the costs come down is shown below. (Figure 1)

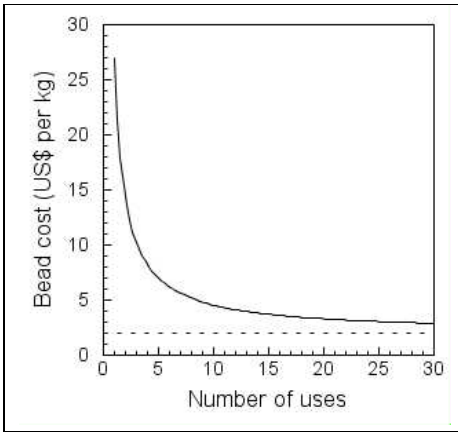

Figure 1. Calculation to show decline in price of drying beads with the frequency use. Note the price drops to an asymptote just above the fixed reactivation cost after about 10 uses.

Experiments

This project has a number of new and ongoing studies that have occurred throughout the year in several different countries. In India, Dr. Razia Sultana collected rice, corn, wheat, okra and bottlegourd seed samples from local farmers and seed dealers of Ambala district and sundried the samples for about 5 hours. Then seed samples were packed in airtight containers along with hygro-thermometers to check equilibrium seed relative humidity (RH) and temperature (T). Dr. Sultana also collected and sun dried seed samples at a temperature as high as 45^{o}C. This caused the RH of those seeds to be less than 25%. The RH and T of seed samples were noted periodically. These samples were brought in airtight containers to Hyderabad for conducting germination tests. These tests will help to determine the effectiveness of air-drying as opposed to beads. In a separate experiment in India, the project also conducted storage studies on green gram, sunflower, soybean, groundnut and onion using drying beads to reduce seed moisture content. Seed quality is maintained and comparison is done between bead dried and other methods. The seed quality parameters like germination, MC, vigour and field emergence of stored seed are being recorded at two-month intervals.

In Bangladesh, the project set up drying bead experiments at Lal Teer and Supreme Seed Company. Detailed data on initial seed parameters demonstrates that drying beads reduced the seed moisture content (SMC) from 8.9-10.3 to 6.5-5.8% within 5 days. (See Table 1).

Table 1:

Company	Seed	Variety	Code	Seed (Kg)	Initial MC (%)	Initial germ (%)	Beads (Kg)	Final SMC (%) (After 5 days)
Lal Teer	Tomato	TM-001	16692	2	8.9	89	715	6.5
Supreme	Tomato (Hybrid)	Red Angel	TM492	0.5	10.3	88	155	5.8

Bead capacity was 15%.

In Tanzania, there are ongoing experiments in Maweni Village. These storage experiments are conducted at farmer's level on amaranthus, nightshade, onion and tomato seeds. The seed storage trials using drying beads results did not show much difference in RH values initially and after three months of seed storage. For all crop species, germination rates were not different between drying beads and open storage containers. The project also conducted experimental storage trials at Hort Tengeru, Arusha. CABI conducted these trials on onion, amaranthus, eggplant and mungbean (for bruchid control) using drying beads. CABI also set up demonstration experiments in Arusha Tanzania. Data for seed eRH and germination in Tanzania are shown below (**Figs. 2,3**). The trials did not use proper storage containers; this is important for drying bead efficacy.

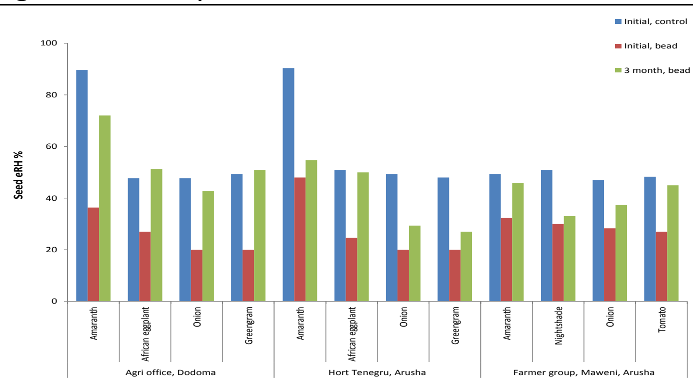

Figure 2. Effect of drying beads on seed eRH of African Indigenous Vegetables (AIV) at three locations in Arusha, Tanzania.

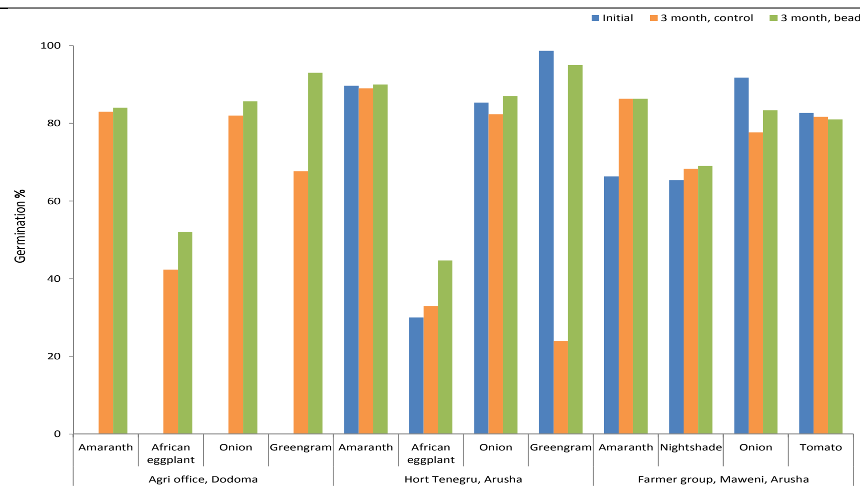

Figure 3. Effect of dying beads in maintaining seed germination of amaranth, African eggplant, onion, mungbean and tomato at three locations in Tanzania. Low initial germination in African eggplant could be due to dormancy. Mungbean seeds were damaged by bruchids in controls but not in bead treatment inside plastic containers.

In Nepal, NARC conducted a new experiment, which will show that it is possible to take advantage of dry weather to dry seeds to low RH, and then preserve that low RH during the rainy season using hermetic packaging (Superbags). This study will demonstrate the dry chain concept. The experiments with the Superbags will show the amount of time it takes to dry larger quantities of seed in a static system. Rhino Research is also working on a "Drybot" system, which would circulate dry air through larger bags or containers to dry the seeds. Additional experiments conducted in Nepal demonstrate the efficacy of the beads in reducing seeds' eRH, but point to some remaining questions regarding bead-treated seeds' viability. The eRH of onion seeds dried and stored with beads were lower than the initial and control treatments for both experiments at Khumaltar and ARS, Dailekh (**Fig. 4**). At Khumaltar, after nine months, onion seed eRH was closer to 20% and germination was closer to 60% (**Fig 5**). The increase in eRH in the treatment from which the beads were removed indicates that the packaging was not fully hermetic. In addition, there was an unusual pattern of rapid loss of viability after 3 months and then little further reduction in viability in any treatment. It is not clear why the seeds in this experiment exhibited this unusual pattern.

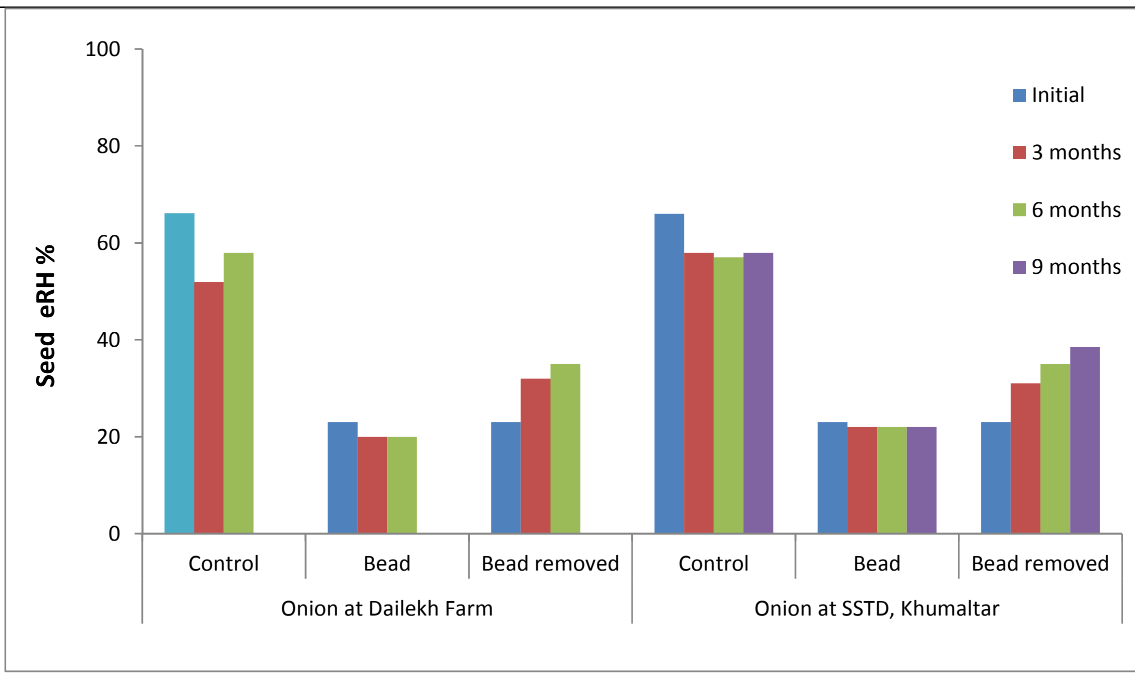

Figure 4. Onion seed eRH following drying and storage until 9 months at Dailekh and Khumaltar.

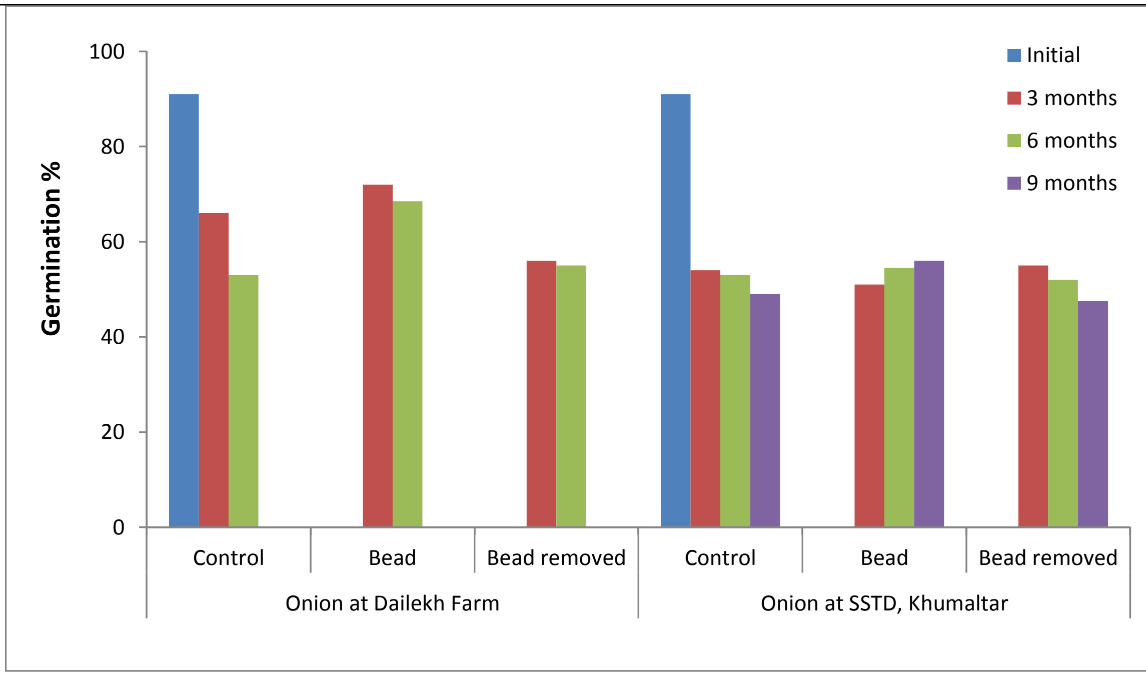

Figure 5. Seed germination of onion seeds dried with bead at Dailekh and Khumaltar until 9 months.

In an additional experiment at the Community Seed Bank in Dallchowki, beads lowered seed eRH of maize, beans and soybeans when compared to initial values (75% RH and 15% MC) (**Fig. 6**). Treatments with continuous beads tended to have lower seed RH compared to those in which beads were removed after 5 days. This could partly be a tempering effect in which moisture in the interior of large seeds can redistribute in the seeds and eventually equilibrate at a higher eRH. However, the continuing increases in eRH over a long time suggest that the containers being used are not hermetic. The ability to monitor eRH makes it relatively easy to detect these problems with storage containers. There was no effect as yet on seed germination in any treatment up to 9 months of storage.

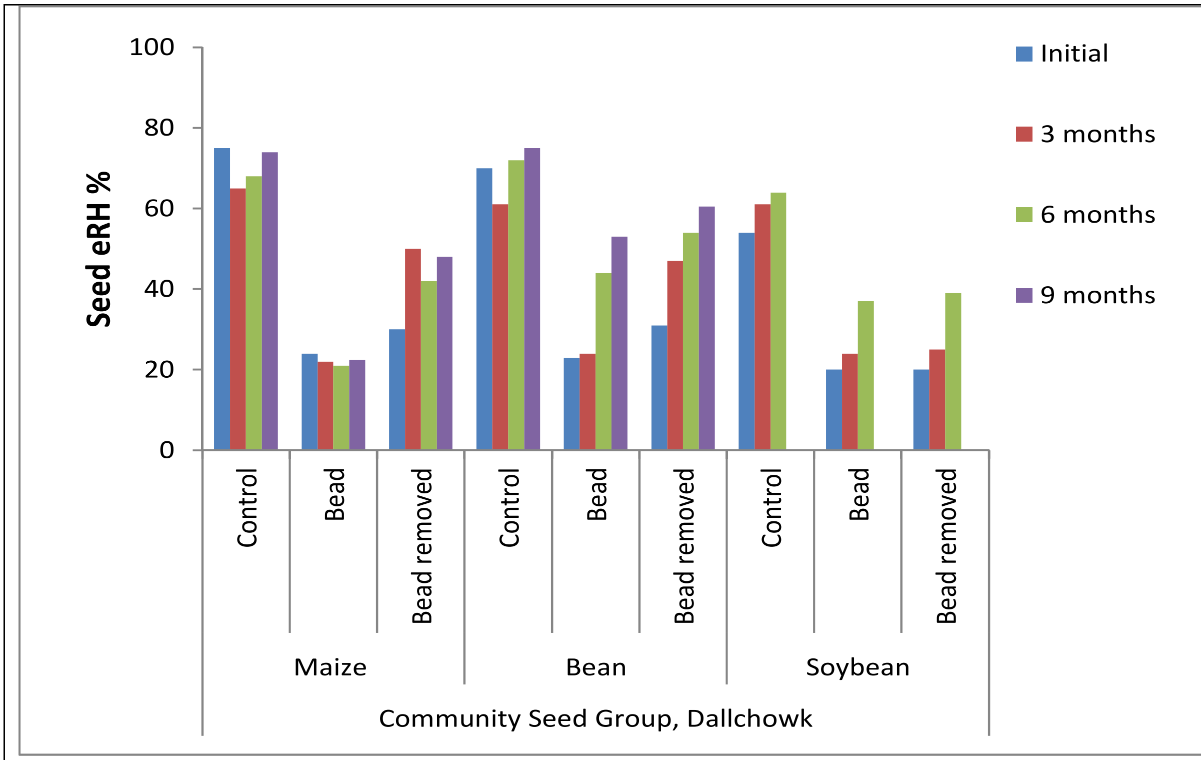

Figure 6. Seed eRH of maize, bean and soybean dried with beads and stored at Community Seed Bank, Dallichowk, Lalitpur.

In Nepal the project also monitored ongoing demonstrations for changes in seed eRH at several CEAPRED sites at Kavre and Rukumand CEAPRED laboratory. Beads lowered seed eRH (**Fig. 7**), but no appreciable difference in germination has yet occurred, except for a trend toward higher germination in bead treatments for okra (**Fig. 8**). Analysis of viability at 9 months is in progress.

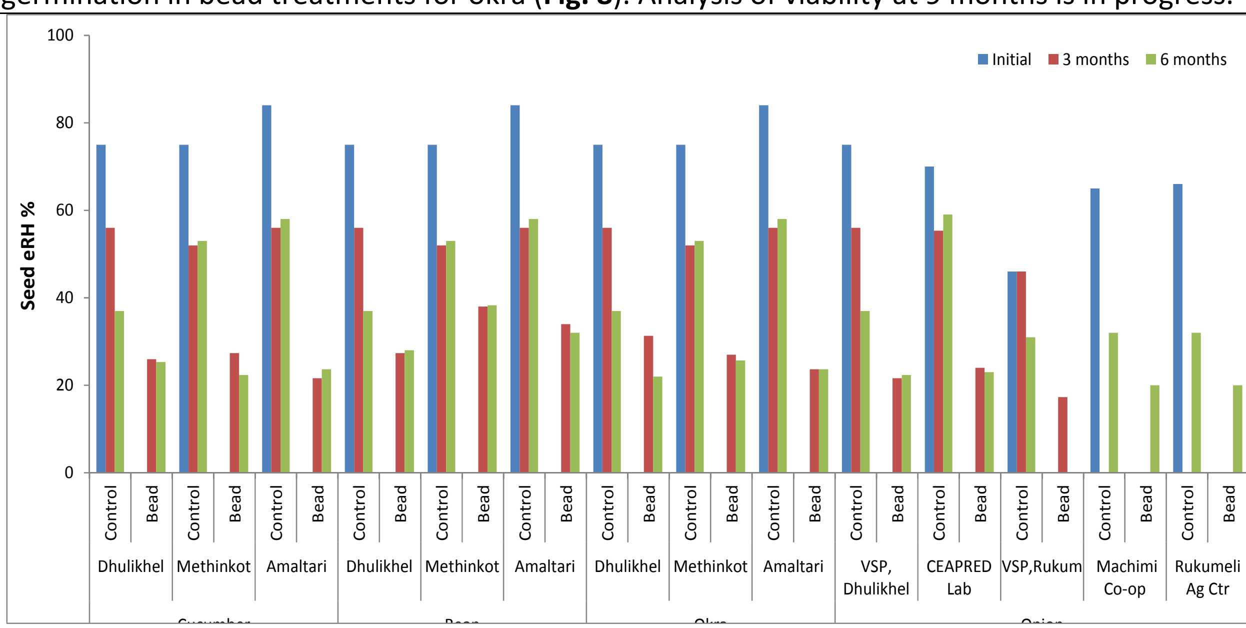

Figure 7. Effect of drying beads on seed eRH at co-operatives in Kavre, Rukum and CEAPRED lab

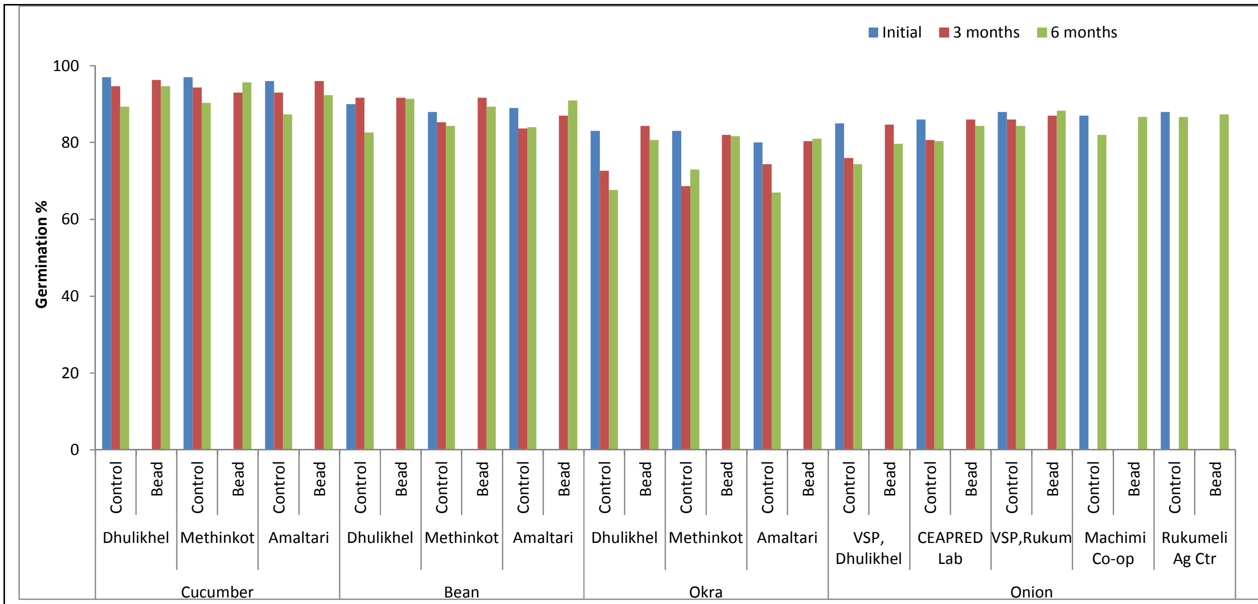

Figure 8. Effect of drying beads on seed germination at co-operatives in Kavre, Rukum and CEAPRED lab in Kathmandu.

Capacity Building:

The project conducted a number of capacity building trainings and workshops for farmers and agrovets. Overall, the program has provided short-term training to 2081 (997 male, 1084 female) farmers, 1776 producers, and 227 people in government. Of the farmers who have received short-term training, 119 have applied new technologies as a result of the trainings. One degree-seeking graduate student and two Ph.D. students are currently affiliated with the program.

The following trainings took place, by country:

US:

- Kent Bradford conducted a workshop with participants from several Central American countries associated with his project to select improved tomato and pepper varieties. Dr. Bradford trained participants (18 total, 6 female) in application of drying beads for storing horticultural seeds and provided with a packet of beads.

India:

- The project conducted a two day for Researchers from State Agri. Universities, ICAR, Seed researchers and MS students. The sessions included training on seed quality components, background of seed drying storage, basic seed storage, the effect of RH/MC content for safe seed storage. The training also covered drying bead technology.

On the second day, the project conducted a demonstration of the drying test where the trainees learned how to estimate the bead capacity and conduct reactivation. On the second day (participants collected data from the drying demonstration and estimation of bead capacity.

Tanzania:

- On June 5, 2013, the project provided training on drying bead technology to seed growers at Maweni village by interacting with seed growers on general seed production practices.
- The project organized an educational program on drying bead technology at Arusha, Tanzania on June 3-11, 2013 where CABI, Kenya had ongoing demonstration experiments. The participants tested the equilibrium relative humidity of seeds inside the containers and compared with ambient RH.
- On June 7, 2013, the project organized a training demonstration on drying bead technology for seed industry and scientists of Horticulture Training and Research Institute, Tengeru. All the participants visited ongoing storage experiment at Horticulture Training and Research Institute, Tengeru and had an interaction about the technology.

Kenya:

- A Demonstration/training program on beads took place on May 6-10, 2013, in Nairobi, Kenya.
- A demonstration and training program was organized at the opening ceremony of the Practical Training Center, which is part of HORTCRSP Regional Innovation Center at Thika, Kenya.

Bangladesh:

- The project conducted a training for six seed technologists of national seed companies Lalteer, Supreme, Metal, ACI, Getco and Partex.
- There was a training on use of zeolite for postharvest drying of seeds for 28 (23 women, 5 men) corn seed producing farmers in Dhading district in August 2013.

Cambodia:

- A demonstration/training program took place at the Royal University of Agriculture (RUA), Phnom Penh, Cambodia at the 3rd Annual Meeting of Horticulture Action Research & Education Network on July 26-27, 2013.

Nepal:

- There was a large-scale demonstration of onion seed drying at SEAN Seed Company and Kathmandu Agro Concern, Lalitpur.
- The project conducted farmer group trainings on bead technology at Lele, Lalitpur and Kavre from June-August.
- The project provided bead technology training for Business & Professional Women (BPW), women entrepreneur groups of Kathmandu chapter (Kathmandu, Bhaktpur, Lalitpur) at soil science division, NARC, Khumaltar
- Short training on bead technology occurred on June 28, 2013 for Junior Technicians at District Agri Development Office from eastern districts at NWRP, Bhairahawa.

- A two-day demonstration and training program on drying bead technology was organized by Horticulture CRSP/CEAPRED, Kavre, at two new co-operatives namely Panchkanya Seed Producer Cooperative, Sarsyunkharka, and Shuvaprabhat Seed Producer Cooperative, Kanpur, Kot Timal on August 13-14, 2013.
- Zeolite beads technology training was conducted at NWRP, Bhairahwa to 20 (12 male, 8 female) technicians of the District Agricultural Development Office.

Thailand

- An "International Training Course on Modern Technology for Sustainable Agriculture System" was organized at Naresuan University, Thailand.. Rhino Research delivered the training on seed technology including "Drying and Seed Storage" and provided free one-kg bead samples to 17 participants.
- Training was organized for bead distributors from India and Australia during August 19-23, 2013. New employees of Rhino research also attended this training on "Drying Beads" at the new Rhino Research Office in Bangkok. There were 14 trainees (female 5, male 9) including 2 dealers each from India and Australia.

Nienhuis Technical Report 2013

Project Name: Producing local, disease-resistant vegetable seed

Countries: Guatemala, Honduras, El Salvador, Nicaragua

Project Description: Acute poverty and meager economic opportunities exist in many rural regions of Central America. Vegetable and seed production are technology-driven economic activities that can significantly contribute to economic growth in communities and families and specifically provide new opportunities that contribute to the economic empowerment of women. The factors limiting this horticultural transformation are access to:

> i) vegetable cultivars with resistance to endemic diseases,
> ii) high quality seed of adapted cultivars,
> iii) business know-how and basic management and marketing skills, and
> iv) connections to regional supply chains that provide stable, predictable markets– Hortifruti Wal-Mart Centroamérica.

Cultivars developed by the World Vegetable Center (AVRDC) have demonstrated tolerance to diseases endemic to Central America. Quality seed can be produced in the tropics in screen houses. The UW Center for International Business Education and Research (CIBER) is a small business incubator. Hortifruti is the dominant regional purchaser, distributor and marketer of vegetables. The supply chain benefits include:

> i) families and women's groups develop technology-based seed and vegetable production businesses within each country.
> ii) access to high quality seed of adapted cultivars reduces risk, minimizes losses and increases profitability in sustainable production for growers, cooperatives and women's groups.
> iii) increased consumption of vegetables contributes to a healthier, more diverse diet.

Collaborators:
USA:
Jim Nienhuis and Suzanne Dove, University of Wisconsin- Madison

Taiwan
Peter Hanson and Paul Gniffke, AVRDC- The World Vegetable Center

El Salvador
Doris Hernandez and Edgar Ascencio, CARE

Guatemala
Claudia Eugenia Flores de Leon, CARE

Nicaragua
Martha Moraga, Maria de los Angeles, Francisco Salmeron and Tomas Laguna, Universidad Nacional Agraria de Nicaragua

Honduras
Donalad Breazeale, Fundacion Hondurena de Investigacion Agricola

Key Accomplishments:

- 18 participants from Honduras, Nicaragua and Costa Rica participated in a drying beads workshop led by Kent Bradford, and women's groups in all three countries adopted the technology. A separate workshop was held in Guatemala, where a women's group also adopted the technology.
- In country partners evaluated 10 tomato lines from AVRDC, and local women's groups selected which of these varieties they wanted to grow.
- Women's groups in El Salvador and Guatemala adopted AVRDC tomato and pepper seeds, and have begun growing seedlings to sell.
- In Guatemala, the Tajomulco women's group produced and sold 1500 tomato seedlings to local growers, and has orders for 3000 more.
- The project is working to build collaborations around grafted seedlings, which have great potential in the region since they can resist soil-borne pathogens.
- Organizational partners in Central America have begun to collaborate as a result of the project.

Technical Narrative

Working with our local partners and women's groups and cooperatives in Tajomulco, Guatemala (CARE), Morazán, El Salvador (CARE) and Tisma, Nicaragua (Univ. Nac. Agraria) and Siguatepeque, Honduras (FHIA), we were successful in introducing and validating new and valuable germplasm (technology) in the region. Through a rigorous process of evaluation involving cooperation among our partners in each country, we have identified ten AVRDC tomato lines as potential cultivars. Women's groups in each of the countries selected their preferred cultivars, depending on adaptation, production and local market demand. All of the new cultivars are resistant to the whitefly vectored Begomoviruses, which is endemic in the region and is the primary limiting factor in production. Thus, the countries and the more importantly the women's cooperatives have access to and ownership of germplasm of open-pollinated tomato and chili pepper cultivars that they can produce at low cost and are now independent of the expensive F1 hybrid seed sold by multi-national seed companies. Our cooperators report that the yield and quality of the AVRDC cultivars met or exceed that of the commercial F1 hybrid cultivars (This is not unexpected as in contrast to other crops, e.g. corn, there is little heterosis in tomato; thus F1 hybrid seed is sold for commercial reasons rather than genetic reasons).

Moreover, the women's groups have gained knowledge and experience in production in protected environments (greenhouses); thus, we have provided access to new knowledge and technology. This combination of knowledge, confidence, germplasm and technology is resulting in the development of small businesses managed by women's cooperatives that produce tomatoes for sale in local markets and is increasingly shifting towards value-added production of seedlings for sale to local growers and cooperatives.

The women's groups in El Salvador, Guatemala and Nicaragua are producing seeds of the selected cultivars and providing seeds to other women's groups in their regions. In Guatemala, we are primarily involved with one women's cooperative, but they are providing seeds of the selected cultivars to four other groups. In addition, the most interesting development related to our project is that the women's groups are not selling seeds of the selected varieties as we had originally anticipated but rather are producing seedlings to sell to local growers. In Guatemala, the women's group produced and sold the tomatoes, and extracted seeds and then produced 1,500 seedlings that were sold at $0.15 (USD) to other local growers. They currently have orders for 3,000 more seedlings. In El Salvador the women's group is also selling seedlings. This is added value, as the seeds alone might sell for one to two cents, but the seedlings sell for fifteen cents.

Of the four countries, the only women's group that is not progressing adequately into production of vegetables and adopting the seed and seedling business is the woman's group in

Siguatepeque (Comayagua), Honduras. They were mentored by the Fundación Hondureña de Investigación Agrícola (FHIA), but apparently the dynamics of the women's group did not result in the development of a cooperative. It is possible that with the introduction of the much more profitable technology of grafted tomato and pepper seedlings that this group might develop into a cooperative business.

The primary concern with the seed and seedling business is that the women's cooperatives need postharvest seed technology. A sister Hort CRSP project directed by Kent Bradford of UC Davis developed the 'Drying Beads' low cost technology for seed drying and storage. Dr. Bradford led a hands-on short course in Madison, WI (August 15-23, 2013) in which he not only provided the drying beads but also led a hands-on workshop explaining in detail the technology associated with drying beads. Due to visa problems only representatives from Honduras and Nicaragua were able to attend. Thus, Jim Nienhuis later traveled to Guatemala and will travel to El Salvador to deliver the drying beads and provide hands-on training in the application of this important technology. We also provided approximately 1 Kg of drying beads to each women's cooperative in each of the countries- this is adequate for each cooperative for many years. The expansion of this technology by other cooperatives will require access and importation of the drying beads. We were quoted $5,000 for six 'mobi-dry' starter packages each containing 6 Kg of beads, thus the approximate cost of the beads is about $100 / Kg. This can adequately dry and store several kilograms of vegetable seeds for many years, thus, it is very cost effective. The challenge is to purchase the drying beads.

The seedlings are a good business, but due to soil borne pathogens I can see that a future endeavor will be to have the women's cooperatives produce grafted seedlings; i.e. graft our virus resistant scions onto soil pathogen and nematode resistant rootstocks. This could have a huge impact, as the women's cooperatives could out-compete the multinationals. This could be a great opportunity in all four project regions. It is value-added at its best. We will partner with another sister HortCRSP project that did training on tomato grafting in Africa led by Matt Kleinhenz of Ohio State University. At the recent meeting of the American Society for Horticultural Science, several papers were presented on success in tomato grafting to combat soil pathogens and nematodes in the state of Florida. I (Jim Nienhuis) visited with the presenters and they shared knowledge regarding the most successful rootstocks (generally these were rootstocks resulting from interspecific hybrids with wild tomato species, e.g. *L. hirsutum*). We will likely have no additional funding after July 2014 for this project; regardless, we will cooperate with Matt Kleinhenz and professors and students at the Instituto Tecnologico de Costa Rica (ITCR) to test this technology. ITCR has already agreed to send a student to UW-Madison to learn and test the grafting technology and later duplicate the experiments in the humid tropics in San Carlos, Costa Rica. Hopefully, we will be able to introduce the most successful graft combinations to our cooperators and friends in Central America through a new cooperative HortCRSP project. The grafted tomato and pepper cultivars is not only a unique technology but it builds upon the entrepreneurial endeavors of the women's cooperatives who innovated within this project to produce and sell seedlings rather than seeds – grafted seedlings represent a value-added technology.

This is a very complex project involving four countries; thus, regional and international meetings are critical for fostering communication among the participants. An unexpected benefit of this multi-country project has been increased awareness of individuals in each country of the regional resources available to them. A good example is Carlos Ramirez of the Instituto Tecnológico de Costa Rica who is not supported by the HortCRSP but who has emerged as the regional expert on construction and management of greenhouses for vegetable and seed production. Also the increased awareness among our three principal partners, CARE, the Univ. Nacional Agrícola and the Fundación Hondureña de Investigación Agrícola of the resources and activities of each institution. This is an unexpected but critical outcome of this project – regional awareness and cooperation.

Capacity Building

21 people (9 women) from 5 countries participated in a short course of seed drying beads held by Dr. Kent Bradford and Dr. Jim Nienhuis at the University of Wisconsin-Madison. The training included a classroom-based workshop on seed drying bead technology, followed by hands-on experiments with the beads and visits to local farms and markets. The goal of the workshop was to build knowledge and confidence around the postharvest physiology of seeds and seed storage.

Three Guatemalans (2 female) were trained on seed drying beads in Guatemala, since they had been unable to attend the Wisconsin training due to visa issues.

In addition, 4 students (2 female) worked on this project. One master's student at UW Madison was fully funded by the project, and three undergraduates from Guatemala and Costa Rica participated in but were not funded by the project.

Publications

Two student theses at the Univ. de San Carlos, Guatemala were completed, one on tomatoes and the other on chili peppers. Both dealt with evaluation of the materials provided by the World Vegetable Center, Taiwan. I do not have the thesis, but the names and titles will be sent to me by Wilder Martinez, Tajomulco, Guatemala. Both Theses have been published.

Horticulture CRSP project technical reports
Theme: Sustainable production of horticultural crops
Project 1: Developing Low-Cost Pest Exclusion and Microclimate Modification Technologies for Small-Scale Vegetable Growers in Benin and Kenya led by Mathieu Ngouajio and Vance Baird of Michigan State University
Project 2: Empowering women vegetable growers with drip irrigation in Cambodia led by Manuel Reyes of North Carolina A & T State University

Project Name:
Low cost pest exclusion and microclimate modification technologies for small-scale vegetable growers in East and West Africa

Project Description:
Rapid urbanization in Sub-Saharan Africa (SSA) has resulted in an increase in demand for food. Almost 33% of the SSA population, close to 200 million people, is undernourished (FAO, 2006). Fruit and vegetable consumption in SSA remains 22-82% below the intake value threshold of 400 g/day recommended by the World Health Organization and Food and Agricultural Organization. This severe malnutrition leads to many chronic diseases among the populations. Vegetable growers, mainly small holders are poor and have no access to inputs for improved germplasm, pest and disease control tools, and improved crop production techniques. Vegetable farms are routinely devastated by pests and extended drought conditions. We propose to harness alternative pest management techniques, micro-climate modifications, and growers' education and training to improve small-scale vegetable production in East and West Africa. A participatory approach will be used to demonstrate efficacy of 1) Eco-Friendly Nets (EFN); insect barrier nettings (either treated or not with insecticides) at protecting vegetables against pests and associated viral diseases 2) floating row covers at improving crop micro-climate and enhancing yield and produce quality, 3) Assess and address farmer's perception of EFN in order to increase the adoption and use of the technology.

Collaborators:
Benin
- Françoise Komlan, INRAB, Benin
- Anselme Adégbidi, Abomey Calavi University, Benin
- Damien Ahouangassi, Association des Personnes Rénovatrices des Technologies Traditionnelles' (APRETECTRA), Benin
- Serge Simon, INRAB/CIRAD, Benin

France
- Thibaud Martin, CIRAD, France
- Laurent Parrot, CIRAD, France

Kenya
- Lusike A. Wasilwa, KARI, Kenya
- Mwanarusi Saidi, Egerton University, Kenya

Tanzania
- Pierre Guillet, AtoZ Textile Mills International, Tanzania

Key Accomplishments:
In Kenya:
- Tested effects of EFN mesh size, type (treated or untreated) and color on different crops. Established the effectiveness of nets in improving microclimate conditions and reducing pest populations in a number of crops, including cabbage, tomato, French bean, onion, carrots, and kale.

- Determined that when managing red spider mites, *T. evansi,* in the leafy vegetable Solanum scabrum, Acarcide-treated nets combined with the predatory mite *Phytoseiulus longipes* are more effective than either management technique on its own.
- Net technology adopted by several small scale cabbage growers.
- Better cabbage, spinach beet and tomato yields reported in farmer fields.
- Socioeconomic studies at KARI conducted on socioeconomic and cultural impact of the technology at farm level

<u>In Benin:</u>

- 7 dry season and 2 rainy season trials implemented
- Completed three trials on EFN technology in cabbage and tomato plants. Trials on tomato plants showed that tomato has better growth and fewer pest populations when grown under EFN than without.
- Discovered key factors in farmers' adoption of EFN technology. These include considerations of cost, labor, social influence, and profitability of EFN use.
- 185 farmers trained on the use of insect nets, and four farmers have received assistance from the project.

<u>Technical Narrative:</u>

Kenya

<u>Trials</u>

On-station, researchers conducted several trials on cabbage, tomato, French bean and onion. Trials on cabbage tested the response of different cabbage varieties to the recommended mesh size and different treatment levels with impregnated versus untreated nets. Regardless of variety, cabbage grown under net cover outcompeted cabbage grown under open field production; results showed fewer pest numbers and even better yields of plants under treated nets. Tomato trials compared the performance of untreated nets and impregnated nets; although pest populations were lower under impregnated nets, the yield differences were not significant.

The project also conducted on-station trials in order to determine whether combining EFN technology with companion cropping is effective in managing whitefly in tomato. Additionally, on station trials tested the effects of EFN color on pest control and the subsequent yield and postharvest quality of tomato. Trials on French bean and onion established that EFN covers improved microclimate conditions while reducing pest counts; this resulted in better yields of both French beans and onions. On station trials are also assessing the effect of EFN color on French bean, carrot, and Kale. Most results obtained in the on-station trials were successfully replicated in farmer fields.

At KARI, researchers conducted several trials. These attempted to optimize use of colored EFNs for production of tomatoes and kales, determine pest effects on watermelon, melon and French beans, and optimize management of diseases of tomatoes under EFN.

At Icipe, researchers examined the effects of Acarcide-treated nets on the behavior of the red spider mite *Tetranychus evansi.* At low population, *T. evansi* migrates and settles to the bottom leaves of the leafy vegetable Solanum scabrum. At high population density, *T. evansi* migrates to the top level of the plant. High populations of *T. evansi* result in huge losses of Solunum scabrum, and in severe cases, death. *Phytoseiulus longipes* is a predatory mite preys on *T. evansi*. Testing attempted to discern the effects of the Acarcide treated nets, with and without the release of *P. longipes*, on the T. Evansi populations in *Solunum Scabrum*. Greenhouse tests showed that:

- Direct spray of acaricide kept density of *T. evansi* low, but started to increase 3-4 weeks after spraying.
- *P. longipes* reduced *T. evansi* density gradually, with lowest numbers recorded at the middle and bottom leaves. There was a gradual increase of *T.evansi* recorded on top leaves two weeks after the introduction of *P. longipes.*
- Acaricide treated nets reduced *T. evansi* density and kept it low. However, higher numbers were recorded on the middle and bottom leaves, compared to top leaves.
- Acaricide treated net combined with *P. longipes* reduced and maintained the lowest density of *T. evansi*, with reduction of density at upper, middle and bottom leaves. This result was comparable to Acaricide direct spray on the plants but did not result in new infestations.

<u>Adoption</u>

Patrick Muthee, a socio-economic student at Egerton University, collected preliminary data on farmer adoption of nets as a pest control method. Patrick is compiling and analyzing the data. In addition, researchers continued to work with farmers at Limuru to understand the challenges that farmers may experience while using EFNs. At KARI, a socioeconomist (Agatha Daniel) partnered with other team members to study socioeconomic and cultural effects of the EFNs at Limuru. The team will share the report soon.

Benin

<u>Trials</u>

From April to September 2013 three trials were completed and two new ones established at the research station. Trials on cabbage re-tested the efficacy of neem oil-based products on cabbage pests. Results indicated that TopBio and pure neem oil have significant effects on *Spodoptera littoralis* and on aphid feeding on cabbage. In June 2013, researchers conducted a trial on the effect of insect net color in order to evaluate the effects of net color on major cabbage pests, plant growth and microclimate. Data collection is ongoing.

Researchers conducted two trials on tomato. First, re-trials on tomato revealed low branching of plants of the control plot compared to those under the nets. Additionally, tomato virus infestations were higher in the control plot than in net-protected plots. These results also confirmed those obtained in the 2011 offseason trial, which showed that tomato plants grow faster under blue, silver and yellow colored nets than under white, rainbow skies and control nets. Virus infestations were generally delayed on all plants grown under insect nets. The second tomato trial on the effect of mesh diameter (0.4 mm and 0.9 mm) on tomato pests was established during the 2013 rainy season (June). This trial was a repetition of the same trial conducted in 2011's rainy season. Data collection is ongoing. Finally, an experiment was conducted by an MSc student on tomato intensification under Insect nets. The combined effects of insect net and planting density on microclimate modification and plant growth were evaluated. Results are inconclusive.

Adoption:
When examining farmers' adoption methods, researchers attempted to (1) assess small-scale farmers' general preferences for different insect management methods, (2) test if preferences for the different methods vary among farmers, (3) identify factors determining this variation, and (4) compare costs and benefits of different management methods, including the use of EFN.

Results indicate that farmers prefer management methods with low-cost and low-labor inputs. Many farmers were dissatisfied with the labor demands of EFN. After labor and cost, variables such as level of training (involvement in a trial on EFN), amount of land allocated to vegetable production, EFN performance, and social influences surrounding the technology were the main factors influencing farmers' perceptions and likelihood of adoption. Farmers do not have strong preferences regarding "time to be effective" (time between the application of the method and effective insect control). 18% of farmers expressed interest in EFN compared to their current practices while 35% find that they were no more interested in EFN than in their current practices. The remainder of farmers expressed negative interest in EFN.

Another critical issue with EFN adoption is profitability. The research team established that cost of on-farm cabbage protection using EFN is three times higher than farmers' practices. Any increase in this cost will increase the cost difference. The profitability rate varies with farmers' categories according to land size allocated to cabbage production. It correlates negatively with the land size under net use and positively under the farmer's practices.

Over 75% of BioNetAgro project beneficiaries have adopted insect nets for nursery protection. Nine beneficiaries adopted insect nets for use on cabbage crops.

Capacity Building

Kenya
At Egerton University, one MSc student graduated in July 2013, one MSc student successfully defended their thesis and is scheduled to graduate, one PhD student collected preliminary data, and two new students who joined the project successfully defended their proposals and have embarked on their field work. 400 BSc students, 370 Diploma students (500 male & 270 female) and 417 visiting high school students (226 male & 191 female) received training in EFN technology at Egerton University. In September, Egerton and the Ministry of Agriculture also organized a field day in Nakuru North District demonstrating EFN technology.

KARI has given both male and female M.S and B.S students the opportunity to conduct research. The students come from various local universities: Kenyatta University (5), Kenya

Methodist University (1), University of Eldoret (1), Moi University (1), Kenya University of Technology (1), and the University of Nairobi (2).

In the Njoro area of the Rift Valley, farmer training in EFN use continued. Extension officers introduced EFNs to farmers' fields to enable the farmers to compare effectiveness of the nets on cabbage and tomato pests and microclimate conditions. Fifty four additional farmers were recruited into the project in Njoro.

<u>Benin</u>
One MSc Student graduated with Master 2 Hortimet at Sup'Agro Montpellier (France). 3 BSc students are interns in the project at INRAB

To date, 185 farmers have been trained on the insect net use. This year, six new farmers joined the project. Researchers conducted training sessions on physical control and insect net use for farmer participants. Over 100 vegetable growers participated in this training throughout the Tori-Bossito and Come municipalities. Four farmers organizations have received assistance from the project.

In addition to training on net technology, the project also provided capacity building activities on the economic aspects of the projects. Six surveyors received training on profitability and economic concepts. Four farmers were trained on cost-benefit data management.

<u>Publications:</u>

Achieng'a FC, M Kasina, J Mbugi, L Wasilwa, M Ngouajio, P Kipyab, and T Martin (2013) Infestation of tomatoes (Solanum lycopersicon L.) by pests when protected with Agronets in Central Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013.

Gateri JW, P Kipyab, L Wasilwa, PA Kamau, M Ngouajio, T Martin and M Kasina (2013) Pest infestation of cabbages under different Agronet deniers and structure height. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 56

Guantai G, M Kasina, J Mbugi, S Mwaniki, L Wasilwa, M Ngouajio, and T Martin (2013) Comparing efficiency of cover duration and mesh size of pest exclusion net covers against cabbage (Brassica oleraceae var. capitata) pests in Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 53

Juma V, M Kasina, L Wasilwa, E Kokwaro, P Kipyab, F Kariuki, M Ngouajio and T Martin (2013) Tomato (Solanum lycopersicum L.) protection with Agronets affects pest population and yields under Kenya growing condition. First International research

and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 52

Kiptoo J, M Kasina, P Kipyab, L Wasilwa, F Wanjala, M Ngouajio, T Martin (2013) Evidence of cabbage-pest suppression using low-cost exclusion nets at Kabete and Thika, Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013.

Martin T., R. Palix, A. Kamal, E. Delétré, R. Bonafos, S. Simon and M. Ngouajio 2013. A repellent treated netting as a new technology for protecting vegetable crops. Journal of Economic Entomology 106(4): 1699-1706 (2013); DOI: http://dx.doi.org/10.1603/EC13004

Muleke EM, Saidi M, Itulya FM, Martin T and Ngouajio M. 2013. The Assessment of the Use of Eco-friendly Nets to Ensure Sustainable Cabbage Seedling Production in Africa. Agronomy, 3(1): 1-12.

Saidi M, Gogo OE, Itulya FM, Martin T and Ngouajio M (2013) Microclimate modification using eco-friendly nets and floating row covers improves tomato (Lycopersicon esculentum) yield and quality for small holder farmers in East Africa Agricultural Sciences Vol.4, No.11.

Sakwa R, F. Olubayo, L. Wasilwa, M. Ngouajio, P. Kipyab, T. Martin and M. Kasina (2013) Effects of Agronets on French bean (Phaseolus vulgaris l.) pollination in Nairobi Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 59

Simon, S., Assogba Komlan F., Adjaïto, L., Mensah, A., Coffi, H., Ngouajio M. and Martin, T., 2013. Insect nets performance on field cabbage production is affected by mesh size, net removal frequency and induced microclimate. Submitted to International Journal of Agricultural Sustainability

Too A, E Kiprop, M Otipa, L Wasilwa, T Martin, Ngoujio M, and Kasina M (2013) Disease manifestation and management on nursery tomatoes (Solanum esculentum Mill.) protected from insect pests using agronet in Kenya. First International research and innovation conference, Mt Kenya University, August 28-30, 2013. Book of abstract page 63

Vidogbena F. and Simon S., 2013. Physical control of cabbage and tomato pests in South Benin. Ecole-Chercheur Ecohort, Sète, 11-14 of March 2013. In preparation.

Project Title: Empowering Women Vegetable Growers with Drip Irrigation
Country: Cambodia

Project Description: Horticulture crop production, a women's domain in Southeast Asia, is plagued by yield losses because of drought, and unequal opportunities for women (Chiong-Javier, 2009; Holmes and Slater, 2008; Spieldoch, 2007). Among the main introduced technologies in horticulture, drip irrigation has been shown to replace time consuming tasks of hand irrigation and fertilization, increase yield and quality of horticulture crops, reduce pests, and save water (Palada et al, 2010a, 201b; Ella 2008, Ella et al, 2009, 2010, and 2012; and Reyes, 2009, 2008, and 2007). When targeted at women, drip irrigation has been also found to increase women's productivity and income, enhance their welfare by reducing drudgery, decreasing workload, improving health and saving time for other practical needs, as well as empowering them with a stronger voice in the family and community (Upadhyay, 2003).

The project will target a rural site in Siem Reap, Cambodia. The area is home to several grand temples like Angkor Wat, which is a popular tourist destination. Vegetables can be marketed in restaurants and hotels serving the tourism community where only 30% of vegetables are supplied from Cambodia. Hence, the women of Siem Reap can supply pesticide-free fresh vegetables to the market that is at most 1 hour away.

Collaborators:

USA:
Manuel Reyes and Don Edralin. North Carolina A&T State University

Cambodia:
Chansereivisal Duong and Yun Sinang, Agricultural Development Denmark Asia

Key Accomplishments:

- Partners identified 3 women's groups to pilot the irrigation project
- Women's groups were trained in using irrigation with conservation agriculture practices
- 15 drip irrigation systems installed in participating women's households
- Women's groups grew cucumbers (2 groups) and kale (1 group) using drip irrigation
- Women's groups are recording their costs, time spent and income generated so the project can conduct a cost-benefit analysis

Technical Narrative

We began meeting with women and Danish partner: "ADDA" in December 2012. We chose the villages and 3 women groups we will work with and completed and submitted the proposal March 2013. The women's groups were chosen based on water availability during the dry season, at three elevations, the lower, middle and high elevations in relation to Lake Ton Le Sap. Since this is a joint project with SANREM, we were able to send a Ph.D. graduate student, Don Immanuel Edralin (paid by SANREM) to implement the treatments. Reyes visited with Don in June and we found a very good field technician, translator and tuk-tuk owner, Ren Ry. We installed three drip irrigation systems in three households from each women's group/village. Reyes left and Ren and Don completed the 12 other installations. The women decided that to plant kale in one women's group and the two other women's groups planted cucumber. Before Don returned to the USA (Don was there from May to August 2013) the women had already started harvesting cucumber. Ren continued the data gathering and the poster contains the yield for cucumber. Cucumber yields were higher in the drip-irrigated system than traditional although the difference was not statistically significant at the 5% level. We just got the yield for kale and we are still analyzing it. The women chose string beans as their next crop. One women's group whose village is at the lowest elevation was unable to plant because of flooding. We expected that to happen when we chose the groups. The women's groups are recording monies earned and are estimating time spent in farming operations especially irrigation. They are also recording their sales. We have all the costs for fixed costs which are the tanks (most expensive) and drip tape and some accessories. They are not more than $200 per household. We will still complete the economical benefit-cost analysis and will do this after recording yield during the dry season.

Capacity Building:

- The two Cambodian partners who work at ADDA were trained on drip irrigation and conservation agriculture practices.
- Ren Ry, the tuktuk driver, was trained as a field technician for the project.
- Don Edralin, a NCA&T PhD. Student, conducted research in Cambodia over the summer.
- The 15 women's groups who received drip irrigation systems were trained on how to do conservation agriculture with drip irrigation.

Presentations and Publications

Edralin, D.I. and M. Reyes. Conservation Agriculture with Drip Irrigation in Siem Reap, Cambodia. Poster presented at the Water Education Symposium held at Chattanooga, TN, September 24-26, 2013.

Horticulture CRSP project technical reports
Theme: Postharvest
Project 1: Extension of Appropriate Postharvest Technology in Sub-Saharan Africa: A Postharvest Training and Services Center in Benin, Ethiopia, Ghana, Kenya, Rwanda, Tanzania, and Uganda led by Diane Barrett of University of California, Davis
Project 2: Sustainable Development of Horticultural Crops in Zambia by Introducing Postharvest Technologies and Practices for Food Security, Income Generation and in Support of the Tourism Industry in Zambia led by Jim Simon of Rutgers University
Project 3: Developing Training Materials to Improve Postharvest Practices in Guatemala and Honduras led by Jeffrey Brecht of University of Florida

Project name: Opening a Regional Postharvest Training Center

Countries: Rwanda, Ghana, Kenya, Tanzania, Benin, Ethiopia, Uganda

Project Description:

Physical losses of horticultural crops postharvest continue to range from 30-80% in Sub-Saharan Africa (SSA), and problems with food quality, safety and nutritional value are well documented. While past projects have identified appropriate postharvest technologies and recommended a variety of training, capacity building and small-scale infrastructure development, no single project has integrated all of this information and offered a locally based solution. This unique pilot project for smallholder farmers in Arusha, Tanzania, combined a wide variety of training programs, adaptive research and demonstrations of postharvest practices and services aimed at reducing losses and increasing shelf life. Via a postharvest shop set up nearby in Njiro, it will provide on-site ready access to the tools and supplies people need in order to reduce postharvest losses and improve market access and incomes for the smallholder farmers, women farmers and village level processors in the northern zone of Tanzania who are affiliated with established cooperatives and farmers associations near Arusha.

The project site in Tanzania will serve as a model for postharvest development in six additional SSA countries, whose representatives participated via collaboration with African partners. By the close of project, 36 postharvest specialists from the 7 SSA countries involved will be well qualified to implement enhanced postharvest handling techniques. They have already extended postharvest information and training on improved handling practices to approximately 16,000 smallholder farmers and village level food processors in their home countries. Many of those trained have gone on to share their training with others (a multiplier effect reaching about 15,000 additional trainees), and the initial monitoring and evaluation completed during the project showed that those who receive training are using their new knowledge and skills. This has resulted in reports of increased consumption of higher quality produce and better returns on investment for smallholder producers and rural women.

Collaborators

USA
Principal Investigator:
Diane Barrett, UC Davis

Co-Principal Investigator:
Jinru Chen, University of Georgia
Lisa Kitinoja, World Food Logistics Organization

Collaborators:
Marita Cantwell, Michael Reid and Veronique Bikoba, UC Davis
Dan MacLean and Robert Shewfelt, University of Georgia
Symantha Holben, Farbod Youssefi and Lizanne Wheeler, World Food Logistics Organization

Tanzania
Co-Principal Investigator:
Ngoni Nenguwo, AVRDC

Collaborators:
Bertha Mjawa and Ester Meela, Ministry of Agriculture and Food Security

Key accomplishments

- 36 postharvest specialists (53% women) from 7 countries in sub-Saharan Africa trained in running postharvest training programs
- These 36 specialists extended postharvest information and training to approximately 16,000 smallholder farmers and village level food processors in their home countries
- M&E shows that people who received this training are using their new knowledge and skills
- The “Small scale handling postharvest manual” for horticultural crops was translated into Swahili
- Postharvest training and services center established in Arusha, Tanzania on the AVRDC campus
- The PTSC shop opened at the Ministry of Agriculture and Food Security in Njiro, Tanzania (5k from Arusha)
- Many postharvest demonstrations set up at the PTSCs in Arusha and Njiro. These included improved packages, field packing, grading/packing stations, small-scale coolers and processing equipment, and more.
- Local trainees and project leaders conducted training programs at the centers, reaching 637 participants (203 men, 407 women)
- Graduate students from UC Davis, University of Georgia, and the AVRDC were involved in postharvest research for the project.
- Many of the 36 postharvest trainees received scholarships for graduate studies, fellowships, awards, project grants, and invitations to speak at conferences.

Technical Narrative

This pilot project resulted in building local capacity in Sub-Saharan Africa by intensively training 36 individuals from seven countries as postharvest trainers and extension specialists. Their subsequent efforts in training, adaptive research, outreach and extension services during the course of the pilot project has already reached more than 16,000 members of farmers associations and women's cooperatives in Sub-Saharan Africa, plus another 15,000 via the multiplier effect.

The majority of postharvest training and demonstration activities implemented during this project utilized the publication “Small scale handling postharvest manual: A manual for horticultural crops” in English as a resource. As part of the project’s extension accomplishments this manual was translated by Dr. Bertha Mjawa and her MAFS postharvest team. It is now available for free download from UC Davis in Swahili.

Specific Project Objectives and Outcomes

Project objectives focused upon the accomplishment of three major activities, each contributing to the overall goal of building the capacity for long-term, sustainable local horticultural business development. The project was promoted via a wide range of media as each objective was achieved.

Objective # 1. Train 30 persons (researchers, extension workers or development workers) from Rwanda, Ghana, Kenya, Tanzania, Benin and Gabon as postharvest specialists (Year 1). This activity was designed and led by Lisa Kitinoja, with assistance from Diane Barrett.
• The pilot project resulted in the successful training of **36 young people** from seven SSA countries (Rwanda, Ghana, Kenya, Tanzania, Benin, Ethiopia and Uganda) out of an initial group of 49 people.

• These 49 were selected as candidates out of a pool of more than 200 applicants.
• 44 participants were initially accepted as trainees after rigorous evaluation of their written applications and self-administered Training Needs Assessments (TNAs). The only trainee who applied from Gabon was accepted but dropped out just as the training program began, and 9 of the 13 trainees who were accepted from Rwanda did not complete the program. Five additional trainees from Ethiopia and Uganda were added in early 2011 based upon the recommendations of our Hort CRSP project team, UGA and UCD colleagues.
• 53% of the trainees who completed the program were women (19 of 36)
• Each trainee completed 10 assignments (reading, fieldwork, written reports) on Commodity Systems Assessment (CSA), postharvest systems research (PSR) techniques, postharvest demonstration and extension program design, and cost-benefit analysis. The majority worked in English, but four of the trainees (from Benin and Rwanda) submitted their assignments in French.
 Each of the 36 who completed the program received a Postharvest Tool Kit, and 32 of the ToT group attended a week long closing workshop at the PTSC in Tanzania in October 2012, where they participated in farmer training on site.
• The same self-administered TNA was given to the 32 ToT group on their last day of the workshop, and analyses indicate that each of the trainees rated themselves higher on a wide range of knowledge, skills and expertise related to postharvest training and extension work.

Objective # 2. Design and set up a Postharvest Training and Services Center (PTSC) in Kigali, Rwanda (Year 1). The goal was for this PTSC pilot project to serve as a successful model for future large-scale projects in Africa, with funding provided for expansion into many new sites and countries.
• During March 2011, three of the original PIs visited Rwanda to identify potential sites for the PTSC (Barrett, Kitinoja and McLean)
• The first potential African partner organization identified in the grant proposal (KIST in Rwanda) was not able to complete their negotiations to identify a site for the PTSC near Kigali, and most of our Rwandan ToT participants had dropped out, so we were given permission by the Hort CRSP management team to move the project to Tanzania in early 2012.
• The PTSC facility and demonstrations were successfully designed by Lisa Kitinoja after a brief visit to Arusha for site identification in May 2012, and set up by an AVRDC team led by Victor Afari-Sefa on the campus of AVRDC just outside of Arusha, Tanzania. Renovations were completed in September and postharvest training programs there were launched in October 2012 (the beginning of Year 3).
• A Tanzanian PTSC manager (Radegunda Kessy) was hired by AVRDC and trained by Kitinoja and the project team during July 2012- December 2012 in basic skills of postharvest technology, center management, program marketing, inventory control, staff supervision, inventory management/pricing, fee setting and recordkeeping.
• Procurements for the PTSC shop, demonstrations and training programs began in July 2012 and were successfully completed by July 2013.
• In March 2013 the AVRDC directors informed the Hort CRSP project leaders that they would be unable to open the PTSC shop to the public as planned due to certain legal issues they had encountered in Tanzania. After several months of inquiries into alternatives and options for the retail operations, in July 2013 the postharvest shop (with its assorted inventory and sample training/demonstration supplies) was relocated to a nearby Ministry of Agriculture and Food Security (MAFS) site in Njiro (about 5 km from Arusha).
• The PTSC shop in Njiro will generate a variety of sources of income if managed successfully, from fees for services, sale of tools and supplies such as temperature probes, refractometers, plastic crates

and other improved packages, and rent-to-own or leasing agreements for the use of solar driers, cool storage space or shipping assistance. Earned funds will enhance the sustainability of the project, and will be put toward paying for training program costs, utilities and/or for inviting resource persons to visit the PTSC at Njiro to provide postharvest training as the need arises.

Objective # 3. Provide demonstrations, training programs and conduct adaptive research on innovative small-scale appropriate postharvest handling, food safety and food processing methods at the PTSC in collaboration with Trainees and local extension personnel (Years 2 and 3). Due to the change of the PTSC site to Tanzania these activities began in project year 3, when a postharvest specialist, Ngoni Nenguwu, joined the staff of AVRDC in Arusha.

• A wide variety of postharvest demonstrations were set up at the PTSCs in both Arusha and Njiro. These included appropriate, cost effective technologies such as use of shade, improved packages such as plastic crates, field packing, grading/packing stations, simple postharvest equipment such as washing, evaporative cooling, portable FA cooler and small scale processing equipment and supplies, a zero energy cool chamber, and a small insulated cold room equipped with a CoolBot controller. Specifications for demonstrations were based on published research and review articles (Kitinoja and Al Hassan, 2012; Saran et al, 2012; Kitinoja and Thompson, 2010; Winrock International 2009).

• A series of postharvest training programs on a wide variety of topics were designed and implemented during October 2012 through September 2013 by project leaders and local postharvest trainers. More than a dozen Tanzanian and international postharvest instructors provided 42.5 days of training, with 637 participants (230 men, 407women). See Tables 1 through 6 for full details of PTSC training events and the activities implemented by the 36 postharvest trainers.

• The project leaders provided on-going technical support for project staff, association members involved in postharvest training programs and AVRDC staff involved in the day to day operation and management of the PTSC.

• Graduate students from UC Davis, UGA and AVRDC were involved in a variety of postharvest research activities associated with the project. AVRDC had a student intern during the summer of 2013 that assisted Ngoni with some simple data collection on the use of the ZECC.

• UGA graduate student Sara Sparks applied a systems approach to postharvest handling for two purposes: (1) characterization of all factors affecting quality, safety, economic and social aspects and (2) identification of key actors and actions within the system. Ms. Sparks found that mapping the system allowed areas that need improvements to be identified and the impact of new postharvest technologies become evident. Analyzing Commodity Systems Assessment worksheets generated during a previous project, she determined that farmers had specific postharvest concerns with handling practices, maturity at harvest, grading, sorting and inspection, storage, transportation and access to markets and credit.

• Adaptive research was planned on pest control, low cost cool chambers, improved solar dryers, cool transport in insulated containers, food safety and/or other topics but the research studies have not yet been carried out by the AVRDC staff that were assigned to do so and hired for the project. Several meetings were held on the planning process, and visits were made to Africa by the PIs and the Hort CRSP management team in order to kick-start the process. In June 2013 a no-cost extension was granted by Hort CRSP to AVRDC in order to allow them more time to carry out some of these research studies. All of the other project objectives were completed by the original end date of Sept. 30, 2013.

Project Impacts

Measurement of adoption of improved postharvest practices and the related reduction in food losses, with expected subsequent improvements in income was undertaken during 2013, but since the project

got such a late start, we mainly have anecdotal reports.
M&E field visits, observations and interviews were undertaken by Lisa Kitinoja (LK) during August 2013 in and around Arusha. Focus group meetings were held with 4 of the many groups who had attended various training programs at the PTSC during PY3. During the focus groups, LK learned about adoption rates, reported impacts, and what follow up postharvest training the groups wanted.

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Capacity Building

<u>Postharvest trainees</u>

- 36 people (19 women and 17 men) from 7 countries in Sub-Saharan Africa completed the postharvest training of trainers program. The participants represented private businesses, universities, and national research organizations in their home countries. These trainees trained over 16,000 people directly, and reached many more people through the multiplier effect of their training participants training additional people.
- 4 members of the ToT group were hired as independent consultants by AVRDC to provide postharvest training at the PTSC during 2012-2013.
- 3 members of the ToT group were hired as consultants and postharvest researchers by a Hort CRSP funded project in Uganda.
- 3 members of the ToT group were hired as consultants for AVRDC's new postharvest losses project.
- 1 graduate of the ToT program is currently studying for a PhD in France.
- ToT participants are still in mentoring relationships with project leaders, and are also serving as mentors for others.
- Two female trainees received AWARD fellowships.

<u>Other training</u>

- 637 farmer association members, food processors and traders, and women's cooperative members (230 men, 407 women) attended a series of postharvest training programs led by project leaders, the 36 postharvest trainers and other local postharvest trainers. The training topics included general postharvest technologies for horticultural crops, solar drying of fruits and vegetables, food processing and food safety, management and marketing and more.
- Visiting project scientists provided ongoing training and support through workshops at demonstrations at the PTSC.
- 600 people attended training programs held by the PTSC (either on or off site). 933 additional people visited the PTSC but did not attend a training.
- 50 people trained through the Postharvest Education Foundation's e-learning program.

<u>Student training</u>

- The project partially funded one master's student at the University of Georgia.
- 63 Tanzanian diploma students attended a 2-day training on general postharvest handling practices.

Lessons Learned

Future projects modeled upon the PTSC developed under this project must include **all five components** as originally designed in order to make the PTSC financially sustainable

- Training of postharvest trainers (including loss assessment, demo design)
- On-site postharvest training and demonstrations

- Adaptive research, including cost/benefit analyses of potential postharvest innovations
- Postharvest Shop (with tools, goods, supplies) open to the public
- Postharvest services for fees (ex: grading, packing, storage, transport, marketing advice)

Project Name: Sustainable Development of Horticultural Crops in Zambia by Introducing Postharvest Technologies and Practices for Food Security, Income Generation and in Support of the Tourism Industry

Project Description: The goal of this project is to increase food security and generate income for rural farmers through quality production of vegetables. This project enables these communities to have access to appropriate germplasm and involves them in the production, post-harvest handling and commercialization of high value produce to diversify their incomes. Growers also are trained in greenhouse tunnel construction and systems to produce vegetables in open field and under more controlled greenhouses are compared. Access to information is an important component of this project. Farmers are trained not only in production, commercialization of fresh produce but also on business skill development and constraints noted in other communities. This project impacts 100 farmers (55% women) from the communities in the Livingstone region to produce 100 metric tons of vegetables valued of $125,000. This project uses our market-first science-based approach involving private sector buyers, including the Zambezi Sun, Royal Sun, Spar and Shoprite supermarkets, David Livingstone Hotel, Chrismar Hotel and lodges in Livingstone with whom we partner.

Collaborators: From the proposal, the name of the person, where they work, and the country they live in

U.S.
Professor James E. Simon, Principal Investigator

Zambia
Bismarck Diawuo, Country Director, ASNAPP-Zambia

South Africa
Elton Jefthas, Country Director, ASNAPP-South Africa,
Petrus Langenhoven, Agronomist / Greenhouse Specialist

Key Accomplishments: From the narrative. Make this as a list.

- During the reporting period, on-farm training on the production of vegetable seedlings using greenhouse technology was conducted and 15330 seedlings were produced and sold to the value of $1522.
- Crops sold to the Livingstone market reach 1158 tons to the value of $2,034,047
- Conducted field visits with 14 farmer groups with a total number of 274 (female 211, male 63) growers for technical back-stopping in the area of improved production techniques.

Technical Narrative:
<u>CoolBot and Shadebot Construction:</u>

In January two team members (one staff and one Ph.D. graduate student) from Rutgers University visited Zambia to initiate the construction of a CoolBot in Livingstone and Chipata. The CoolBot in Chipata was constructed in collaboration with the USAID funded CASH project. The team finalized CoolBot construction in the end of March and initiated testing that will continue during the next year. The team will also construct a ShadeBot during the first quarter of FY14 at the Nsongwe Woman's Association production site. All structures will be built with locally sourced materials such as burnt bricks, wooden poles and grass for thatching. Building with local materials is an effort to demonstrate to smallholders how they can use materials within their reach to reduce post-harvest losses. The project will use the structures to conduct field demonstrations on the application of good agricultural practices which improve production output and reduce post-harvest losses. The project will also use the structures to show farmers how to maintain simple and affordable cold chain facilities (low tech coolers, with affordable control systems using local materials) to store produce until it is ready to be taken to the market.
The project drafted a CoolBot and ShadeBot construction and installation guide. This is under review at the moment. During the next quarter, the project will produce an extension handout with plans for the CoolBotTM and ShadeBot © in order to facilitate replicability and use.

<u>Trainings</u>
The project will demonstrate and test innovative technologies, along with local materials and practical approaches, with farmers. In collaboration with the USAID funded CASH project, Rutgers University produced four training modules on food safety and practices to reduce postharvest losses and maximize shelf life of fresh produce. Stellenbosch University also contributed to the manual through revisions and input. Training modules will be finalized during the next quarter. The training modules drafted include:

1) Postharvest Guidelines for Fruit and Vegetables in Zambia
2) Postharvest Focus in Zambia
3) Food Safety Protocols
4) Sustainable Agricultural Guidelines for Zambia

<u>Private Sector contributions: Sun International Trust and Zambian Fertilizers</u>
Sun International Trust has agreed to loan Batoka Fresh Produce $120,000. The funds will be used to start up a 'garage' packhouse model and grow it out into a full business within 3 years. Simon and Dr. Maria Marshall (Purdue University) drafted a feasibility plan and submitted to Sun International's Board of Trustees. No feedback has been provided yet.

Zambian Fertilizers sponsored 300kg of fertilizer to the communities of Nsongwe, Linda and Mapenzi. Zambian Fertilizers would like to have a long term relationship with the project and as such will develop an MOU during quarter 1, FY14.

<u>Meetings and Trips:</u>
Drs. Simon and Weller made one trip in November to the Livingstone site to provide additional technical back-up and training in irrigation and postharvest technologies. In February, a Rutgers team visited Livingstone to assist in the construction of the Coolbot™ and the ShadeBot© and to provide training in data collection and field design to Muunga Mapenzi. Simon conducted further trainings for the Nsongwe women on vegetable harvesting techniques and in the Coolbot™ and ShadeBot© in April 2013. (For more information on these trainings, see Capacity Building, below). Dr. Simon, Dr. Weller and Dr. Langenhoven also attended the HortCRSP annual meeting in Nairobi, Kenya from 6-9 May 2013. Simon, Weller, and Langenhoven also attended the opening of the HortCRSP Innovation Center at KARI Theka.

Afterwards, all three travelled with Dr. Maria Marshall to Eldoret, Kenya, where AMPATH collaborators met to discuss project-related issues involving postharvest handling though the major focus was on AIVs.

Visits by Former First Lady Laura Bush and US Ambassador to Zambia:
As part of her trip to Zambia, Former First Lady to the United States of America (USA), Mrs. Laura Bush on June 29, 2013 graced the Nsongwe Women's Association with a visit to their horticulture research and demonstration site in Livingstone.

The United States Ambassador to Zambia, Mark Storella, visited the Nsongwe Women's Association in March 2013 during a cross-border bike ride to promote international tourism, economic growth, and wildlife conservation in Zambia and Zimbabwe.

Capacity Building:

Workshops and farmer training:
Two researchers (Bernard Moonga and Moses Banda) from the University of Zambia (UNZA) attended a postharvest training course at the AVRDC in Tanzania. Both UNZA researchers also attended a one-week intensive hands-on training program at the HortCRSP Innovation Center in Arusha, Tanzania.

A total of two hundred and thirty-one (231) farmers were trained (48 male and 183 female).Farmers received training in the following areas:

- Seedling production: 20 farmers (3 male, 17 female)
- Irrigation management: 24 farmers (6 male, 18 female)
- Postharvest technology: 24 farmers (6 male, 18 female)
- Crop Rotation: 16 farmers (16 female)
- Marketing: 12 farmers (7 male, 5 female
- Compost making : 15 farmers (0 male, 15 female)
- Record Keeping : 24 farmers (8 male, 16 female)
- Land preparation: 28 farmers (10 male and 18 female)
- Planting techniques: 12 farmers (0 male and 12 female)
- Safe handling of chemicals: 5 female farmers
- Harvesting: 15 female farmers
- Leadership/Record keeping: 29 farmers (8 male and 21 female)
- Seed sowing: 7 farmers (0 male and 7 female)

Presentations and Publications

2014. Coppin, J., H.R. Juliani, Q.L. Wu and J.E. Simon. Variation in polyphenols and lipid soluble vitamins in Moringa oleifera, pp 12. In: Preedy, V.R. (ed). Processing and Impact Active Components in Food, Elsevier Press (in press).

2013. Villani, T., H.R. Juliani, Q.L. Wu and J.E. Simon. Hibiscus sabdariffa: Phytochemistry, Quality Control and Health Properties, pp. 209-230. In: Juliani H.R., J.E. Simon and C.T. Ho (eds). African Natural Plant Products. Volume II: Discoveries and Challenge in Chemistry, Health and Nutrition. American Chemical Society Symposium Series 1127, ACS Press, Washington, D.C. USA (in press).

2013. Coppin, J.P., Y.P. Xu, H. Chen, M.H. Pan, C.T. Ho, H.R., Juliani, Q.L. Wu. and J.E. Simon. Determination of flavonoids and anti-inflammatory activity in Moringa oleifera by LC/MS. J. Functional Foods (in press).

Project Name: Developing Training Materials to Improve Postharvest Practices

Project Description:

We propose to develop and produce audiovisual training materials on various key postharvest topics, including narrated PowerPoint presentations and short videos. We will incorporate into the PowerPoint presentations illustrations of the concepts and practices being presented via time lapse photography and short video clips that show the actual practice or change in product appearance occurring. The training materials will be developed in consultation with HortCRSP leaders and participants in order to take advantage of the insights and experience they have gathered working with their projects' clientele.

Collaborators:

USA

Principal Investigators:

Jeffrey Brecht and Mark Ritenour, University of Florida
Luis Cisneros-Zevallos, Texas A&M University

Key Accomplishments:

- Project team made contacts with potential in-country partners (Subject Matter Experts, etc.)
- Project plans adjusted based on information gathered on trips to Guatemala and Honduras.
- List of potential subject matter experts (SMEs) compiled, topic online created for use in SME recruitment
- SMEs for 7 of the 12 topics have verbally agreed to participate.

Narrative:

Our first activity was a trip to Guatemala and Honduras from 12-17 August by the three co-PIs and Hort CRSP Assoc. Dir. Amanda Crump. Guatemala and Honduras are the countries for which we will be creating the training materials that are the subject of our project. We met with USAID personnel, faculty at UVG in Guatemala and Zamorano in Honduras, agriculture sector companies, and the Guatemalan export association. Our goal for this trip was to learn about the agricultural systems in the two countries from subsistence farmers to exporters and to find out from people with experience working with horticultural producers how best to transfer knowledge and tools to improve their success. We also described our proposed project and solicited feedback form everyone with whom we met. As a result of the trip, we gained insight into how the modules of the training presentations should be structured to best benefit producers with different levels of sophistication.

Upon returning from Guatemala and Honduras, the co-PIs discussed moving forward to recruit Subject Matter Experts, specifically following up on an idea from our trip to jointly create the first presentation outline ourselves in order to have a sample that would help the potential SMEs understand what we are looking for. We chose the topic, "Harvesting to Avoid Injuries" and put that together.

We had a conference call with Hort CRSP personnel on 5 September in which we shared our experiences and new insights and discussed how we would move forward. The draft outline for the Harvesting presentation was shared and reviewed.

PI Brecht visited with Mark Bell at the Hort CRSP offices on 24 September and discussed how to incorporate short video clips and time-lapse photography into the narrated PowerPoint presentations. We also discussed our insights from Guatemala and Honduras and how those relate to adult learning and creating effective presentations.

After finalizing the Harvesting outline, the co-PIs discussed and agreed on our plan for recruiting SMEs (including deliverable timeframes/deadlines), re-visited the names of potential SMEs that we had previously compiled, and began contacting the potential SMEs.

Capacity Building:

Capacity building will commence in 2014.

Presentations and Publication:
None yet

Horticulture CRSP project technical reports
Theme: Food Safety
Project 1: Delivering Vegetable Safety Education through Established Social Networks in Guatemala, Honduras, and Nicaragua led by Jeffrey LeJeune of The Ohio State University

Project Name: Delivering Food Safety Education Through Social Networks

Countries: Guatemala, Honduras, Nicaragua

Project Description: Contamination of vegetables with food borne pathogens and spoilage organisms results in food borne illness and economic losses. This problem is worldwide, but is particularly serious in Central American countries that are already fighting problems due to poor nutrition and poverty. Despite the potential magnitude of the problem, small-scale Latin American farmers are generally unaware of these hazards and losses and how these risks can be prevented. The lack of awareness of these risks (and potential benefits realized by their control) complicates communication efforts on the subject and hinders the sustained adoption of safe agricultural practices in horticultural production. We hypothesize that established social networks will provide an effective and efficient venue to communicate vegetable microbial contamination information and promote management changes to improve produce safety and quality. We will test this hypothesis using several social networks (greenhouse associations, organic production associations, health clinics, schools, and traditional Extension outreach programming) to communicate food safety and quality messages. These networks are particularly relevant as they are expected to include a large proportion of female farmers. Increases in awareness among farming communities in Honduras, Guatemala, and Nicaragua will be measured. Successful pathways of communication will be expanded and adoption of food safety practices assessed. At the completion of these participatory research and outreach activities, several tangible goals will be accomplished: Food contamination will decrease, farmer health and produce quality will be improved among participants; new opportunities for sale and trade of produce will be opened, increasing economic viability for farmers; and a model system for effective delivery agricultural assistance in Latin American countries will be validated. These methods can then be applied to communicate other important information to enhance crop production, microfinance, or additional nutritional education.

Collaborators:
USA
Principal Investigator:
Jeff LeJeune, The Ohio State University

Honduras
Co-Principal Investigators:
Alfredo Rueda and Yordana Valenzuela, Zamorano University

Nicaragua
Co-Principal Investigator:
Julio Lopez, PROMIPAC Nicaragua

Guatemala
Co-Principal Investigator:
Eduardo Pretzanzin, Universidad de San Carlos
Key Accomplishments:
- Needs assessment conducted
- IRB approved
- Julio Lopez joined the team as the primary contact at Zamorano

Narrative

IRB approval has been obtained through Ohio State (Continuing Review documents are currently being evaluated) and Eduardo Pretzanzin has been approved as an individual investigator. During the long IRB process, our primary contact at Zamorano, Alfredo Rueda, left the university leaving us with no alternate contact. We have since reached out to Zamorano and have a replacement as the primary contact. Julio Lopez has agreed to be this person. Travel plans have tentatively been set for October 14-19, 2013.

Capacity Building
None is period due to delays with the IRB.

Publications:
None thus far.

Horticulture CRSP project technical reports
Theme: Marketing
Project 1: Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers in Kenya, Tanzania, and Zambia led by Stephen Weller of Purdue University
Project 2: Increasing Food Safety and Creating a Niche in the Market for Smallholders by Educating Them in Production, Postharvest, Food Safety, and Marketing and Branding their Produce According to Specific Food Safety Standards in Cambodia and Vietnam led by Cary Trexler at University of California, Davis

Project name: Strengthening value chain for African Indigenous Vegetables
Countries: Kenya, Tanzania, Zambia
Project Description: Our research seeks to support and strengthen the African Indigenous Vegetables (AIVs) industry using a market-first approach to overcoming constraints along the value chain leading to improved production practices, supply, postharvest handling, distribution and consumer acceptability of AIVs in Kenya, Tanzania and Zambia. Key ingredients are development of a strong public: private sector partnership that ensures activities support needs of consumers and markets and involve germplasm evaluation, development of sustainable production and seed production/saving techniques, improved market access and building capacity of stakeholders through outreach programs at all levels of the AIV value chain. This project will both characterize nutritional attributes of AIVs as well as create awareness of health and nutritional benefits of AIVs through household and market surveys and educational programs about nutrition. We will bridge information gaps through research and promotional activities cooperating with private sector, farmer groups, government, research and NGO communities to build confidence in AIV production and enhancement of farmer adoption of AIV systems. Our activities will build capacity of African universities and institutions involved in research and training of extension personnel who serve the farm community. Improved AIVs will provide nutritional complements to diets. The approach is tailored to local dietary needs and promotes biodiversity and sound environmental management in production while providing affordable edible foods that can be grown and consumed locally or processed. Activities will result in improved income generation, new microenterprises across the value chain, improved availability of nutritious AIVs for consumption and overall improved quality of life.

Collaborators:
Principal Investigators – U.S.A.
Dr. Stephen C. Weller and Dr. Maria Marshall, Purdue University
Dr. James E. Simon, Rutgers University

USA Collaborators:
Dr. Steve Yaninek, Dr. Betty A. Bugusu, and Dr. M. Fernanda San Martin-Gonzalez, Purdue University
Dr. Qingli Wu and Dr. Rodolfo Juliani, Rutgers University

Co-Principal Investigators and/or collaborators from developing countries:
Kenya
Co-principle Investigator
Dr. Pamela Obura, AMPATH Center at Moi Teaching and Referral Hospital / Moi University,

Kenya Collaborators
Dr. Elizabeth Omami, Dr. Julius Ochuodho, Dr. Linnet Serenge Gohole, Dr. Violet Kadenyeka Mugalavai and Dr. Wilson Ng'etich, Moi University
Christine Ndinya and Dr. Martins Odendo, KARI
Naman Nyabinda, AMPATH/FPI

Tanzania
Co-Principle Investigator
Dr. Chris Ojiewo, AVRDC-The World Vegetable Centre

Collaborators
Dr. John Msuya and Dr. Joyce Kinabo, Sokoine University of Agriculture

Mrs. Nancy Kaaya, Horticulture Research Institute
Dr. Don Lotter, St. John's University of Tanzania

Key Accomplishments:

- AIV variety trials conducted in Livingstone and Lusaka (Zambia); trials will be repeated next year.
- 200 baseline household surveys conducted in Livingstone and Lusaka
- The major markets for AIVs in the Lusaka area were mapped
- Zambian farmers were trained on the best agricultural practices for AIVs, irrigation management, postharvest technology, harvesting and postharvest handling, marketing, soil improvement, data collection, land preparation, and good planting practices. 205 farmers in total attended at least one training.
- In Kenya, field trials were held to study the impact of different fertilizer types on the type and number of insect pests of AIVs, the impact of fertilizer type on AIV growth, and the impact of fertilizer type on AIV seed production and quality
- In Kenya, an MS student conducted a research project on improved solar drying for AIVs
- Baseline household surveys and vendor and consumer choice surveys were conducted in Kenya
- Nutrient composition of AIVs was analyzed
- A postharvest market survey was conducted in Tanzania
- Multiple university professors and graduate students in Kenya and Tanzania are involved in research related to the project, in line with the project's objective of building capacity of key research personnel and graduate students

Technical Narrative

Zambia:

Field trials

Livingstone – The first set of trials was planted during December 2012 (onset of rainy season) at Nsongwe Woman's Association. Data was collected from the first agronomic and variety trials except that of seed since the varieties were not allowed to become reproductive. After evaluation of the data it was concluded that the trials are to be repeated due to inconsistencies that could have occurred as a result of a lack of training and experience of data collection staff. A second round of trials was planted in August 2013.

Lusaka – The first set of trials were planted at Chilanga (Lusaka) in January 2013 (rainy season). The establishment of the agronomic and variety trials was good except we had challenges with the establishment of nightshade (very poor germination). Consistent weekly data collection was a challenge due to the distance from the trial plot. However, data was collected (planting date, germination %, plant density, leaf shape, leaf size, number of seed pods per plant, number of seeds per pod, pest, disease and growth observations) on all varieties and these trials will now be used for seed collection. Seeds were harvested from all plots. A second round of trials was planted in August 2013 in the Ngwerere area.

All staff working on the trials will be trained extensively during Q3, year 2 to ensure that data collected is of the highest quality.

Baseline Household Survey

A baseline survey was done for Lusaka and Livingstone. 200 surveys were done; data was entered by ASNAPP staff and analyzed by Dr Maria Marshall (Purdue University). We had 100 respondents in Livingstone (29 female and 71 male) and another 100 respondents in Lusaka (39 female and 61 male).

Partnership

The project has the full support of Sun International. An MOU is being negotiated with Sylva Foods in Lusaka (market). The Ministry of Agriculture and Livestock is fully engaged on the extension side.

Mapping of markets around Lusaka

Major markets for AIVs were mapped in all four extension blocks around Lusaka district. Among the potential markets, Soweto markets, which are located in all four blocks, constitutes more than 50% of the total AIV market in Lusaka while Rose Bloom (North East extension block) accounts for at least 20% of the Amaranthus demand which is supplied to supermarkets such as Pick n Pay and SPAR.

Visit of US Ambassador and former First Lady to Zambia to AIV demonstration site

The United States Ambassador to Zambia, Mark Storella, visited the Nsongwe Women's Association in March 2013 during a cross-border bike ride to promote international tourism, economic growth, and wildlife conservation in Zambia and Zimbabwe. Former First Lady to the United States Mrs. Laura Bush also visited the Nsongwe Women's Association's horticulture research and demonstration site in Livingstone on June 29, 2013.

Kenya Narrative

Experiments at University of Eldoret and KARI on AIV performance, pests and seed production/quality

1. Report on the Crop Pests and Diseases of African Indigenous Vegetables

Kenya collaborators: Dr. Linnet Gohole and MS student Silvia Ajaa Omasaja, US scientists: Drs. Yaninek, Weller and Simon

Field Experiment: Variety and fertilizer evaluation and pests and diseases attacking AIVs - Kenya

Three varieties each of African nightshade, spider plant and amaranth were planted in 2013 with three fertilizer treatments (farmyard manure, synthetic fertilizer and no fertilizer) using a Split-Split plot randomized complete block design with three replications. The main plot was the varieties and the sub plots the fertilizer treatments. The rates of fertilizer applied were 125 kg /ha for the artificial fertilizer and 6 MT/ha for farmyard manure (FYM).

Data collection: Data were collected on insect pest species complex and pest populations over the growing period. Data on pest species complex was obtained by recording the various pest species found in the field for all the AIV varieties. Pest population was determined in the field through direct *(in situ)* counts.

Species Identification: Insect species collected in the field from the various AIV varieties were preserved and taken to the National Museums of Kenya – Invertebrate Department for identification. This was done by Silvia Ajaa Omasaja with the help of insect taxonomy experts at the museum.

The insect pests collected and identified are presented in Table 1. (Note some have been identified to Family or Genus level. Further identification has to be done)

Common Name	**Species name**	**Order**	**Family**	**AIV host species**
Flea beetles	*Phyllotreta* spp.	Coleoptera	Chrysomelidae	Spider plant
Bagrada bugs	*Bagrada hilaris*	Heteroptera	Pentatomidae	Spiderplant
Brown bugs	*Cletus orientalis* *Cletus orchraceus*	Heteroptera	Coreidae	Amaranthus
Cotton stainer	*Dysdercus nigrofasciatus*	Heteroptera	Pyrrhocoroidae	Amaranthus
Black aphids	*Aphis fabae*	Homoptera	Aphididae	Night shade, Amaranthus
Green aphids	*Aphis gossypii*	Homoptera	Aphididae	Night shade, Amaranthus
Green stink bug	*Nezara viridula*	Heteroptera	Pentatomidae	Amaranthus
White flies	Yet to be ID	Homoptera	Aleyroididae	Night shade
Leaf hoppers	Yet to be ID	Homoptera	Cicadeliidae	Spiderplant
Beetle (1)	*Luperodes exclamationis*	Coleoptera	Chrysomelidae	Night Shade
Beetle (2)	*Silidius apicalis*	Coleoptera	Cantharidae	Spiderplant
Black spotted	*Cheilomenes aurora*	Coleoptera	Coccinelidae	Night shade

lady bird				
Lady bird	*Epilachna* sp	Coleoptera	Coccinelidae	Amaranthus, Night shade
Leaf beetle	*Scymnus* sp	Coleoptera	Coccinelidae	Night shade
	Lagria cyanicollis *Lagria purpurascens*	Coleoptera	Lagriidae	Night shade, spiderplant
African bollworm	*Helicoverpa armigera*	Lepidoptera	Noctuidae	Night shade, spider plant
Black beetle	*Nematocerus castaneipenais*	Coleoptera	Curculionidae	Night shade

Generally it was noted that:

- More pests and damage were found on young AIV leaves than on older leaves
- More insects pests were observed on AIVs fertilized with organic manure followed by synthetic fertilizer (NPK) and least on the crops where no fertilizer was applied (Fig. 1 & 2)
- Pest susceptibilities vary with variety and fertilizer practice. Flea beetle damaged was noted more on the Local and the MLSF-13 spider plant varieties than on MLSF-29 and MLSF-15 (Fig. 3)
- A variety of weeds were also associated with the AIVs.

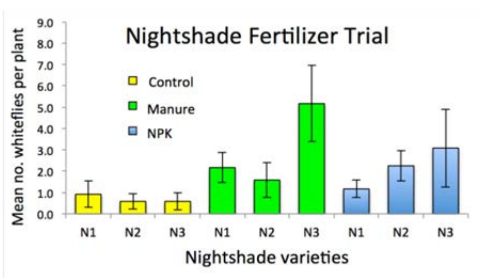


Fig 1. Whitefly infestation on nightshade varieties treated with different fertilizers

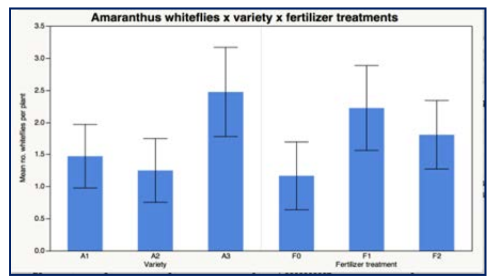


Fig 2. Whitefly infestation on Amaranthus varieties treated with different fertilizers

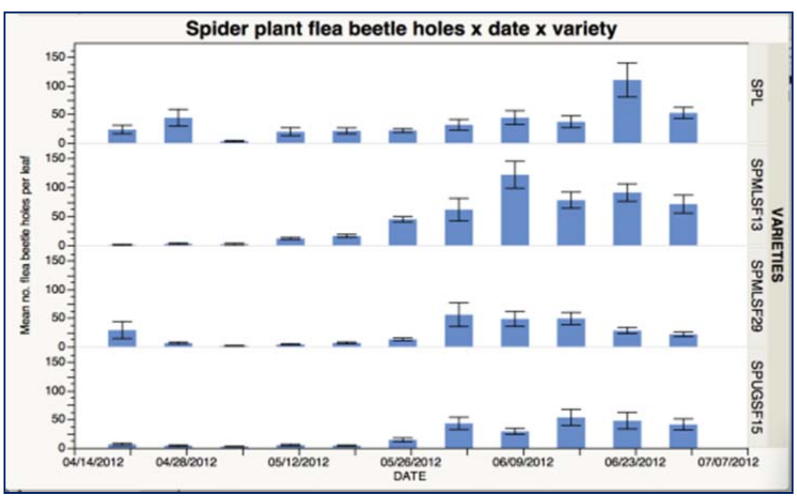


Fig 3. Flea beetle infestation on different spider plant varieties

On-going work:

- Identification of AIV diseases and notation and recorded pictures of weeds. Analysis of pests and disease data on species incidence, abundance, population dynamics.
-

Agronomic trials

MS student Benson Migwi Kibiru under supervison of Prof. W. Ngetich, Dr. E. Omami, Dr. Weller and Dr. Simon.

Experiments have been established to evaluate the effect of fertilizer type and soil pH on AIV growth. Data is still being compiled but initial results suggest that all three AIV species respond well to manure and commercial fertilizers. The pH effect is interesting in that a higher soil pH (6 -6.5) is required for nightshade than for spider plant and amaranth. Data are still being analyzed for statistical differences among the AIV lines tested. However, there were differences in yield among the lines tested in these experiments. One interesting result was that newly emerged spider plant had a heavy infestation of black beetles and Bagrada bugs which would require an insecticide application in order to save the stand.

Effects of different fertilizer types on seed quality aspects of three indigenous vegetables in Western Kenya.

MS student Fanuel Letting, under the direction of Prof. J. Ochuodho, Dr. E. Omami, Drs. Weller and Simon

The production of AIVs is hampered by lack of accessible good quality seed. The proper management practices required for better seed production by the farmers has not been defined for the farmers in the region. This experiment determined the effects of different fertilizer types on seed quality aspects of three indigenous vegetables; spider plant, Amaranthus and black nightshade, planted under three fertilizer types; pig manure, Mavuno fertilizer and no fertilizer during the first season of October 2012-March 2013 at the University of Eldoret research farm. The effects of fertilizer type on the inflorescence length of Amaranthus and silique length of spider plant were studied and seeds were tested for germination. Additionally, the thousand seed weight of the seeds harvested from the field was determined to evaluate the effects of the different fertilizer types on the thousand seed weight of these AIVs.

Data showed that the use of fertilizers has a positive effect on inflorescence length of the two varieties of Amaranthus and spider plant, and that there was a difference between the different fertilizer types. In amaranth the inflorescence length increased with the application of fertilizers (pig manure > Mavuno > no fertilizer).

Silique lengths on lines of spider plant were similar with the three types of fertilizers. In all the varieties, the local variety performed best with mavuno and where there was no fertilizer (F0) application followed by Variety ML-SF-29 and finally UG-SF-15. The three lines showed the least increase in length in the plots with mavuno fertilizers.

Germination of seed collected from the three species was low in all treatments. The tests were conducted one and half months after the harvesting and the low germination percentage may be attributed to lack of after-ripening that the seeds require before optimum germination will occur. This is being further evaluated. There was a difference between the fertilizers types for seed weight for three lines of spider plant as the thousand seed weight increased for plants grown without fertilizers compared to those where fertilizer was used.

There was a difference between fertilizer responses for the different lines of Black nightshade in seed weight with higher seed weight occurring in fertilizer treatments. However, there was no difference between types of fertilizers on thousand seed weight of Amaranthus species but the seeds of the local variety were heavier compared to variety UG-AM-40.

Results suggest that use of fertilizers when growing AIVs leads to increase in the inflorescence size of Amaranthus types but has no effect on silique length of spider plant and leads to an increase in seed weight of spider plant and black nightshade seeds but not for Amaranthus species.

Current experiments are further testing response of the 3 AIV species and lines to fertilizer in terms of seed production and viability.

KARI Experiments with varieties of AIVs for response to fertilizer type and total seed production.
These trials were conducted by Christine Ndinya of KARI
Two experiments were conducted on variety and fertilizer and seed production of AIVs at KARI Alupe Experiment Station. Three varieties of African nightshade, spider plant and amaranth were tested using three fertilizer at rates of 500 kg /ha for the artificial fertilizer (Mavuno) and 537.5 kg/ha for chicken Manure (FYM) or no fertilizer. Experiments are on-going and final yield of crops is to be determined.

Seed Evaluation Trial
Seven varieties of nightshade, amaranth and spider plant (Table 1) were planted using DAP fertilizer as a standard treatment.

Table 2: Nightshade, Amaranth and spider plant varieties planted for the seed production trial

African Nightshade	Amaranth	Spider Plant
BG-16	AC-45	ML-SF-29
SS-49	Ex-Zim	UG-SF-15
Ex-Hai	AC-38	PS
SS-52	UG-AM-40	UG-SF-23
SS0 4.2	Ex-Mwanga	ML-SF-17
Commercial variety	Commercial variety	Commercial variety
Local market variety	Local market	Local market variety

Seed Evaluation Results.
The flowering dates of amaranths varieties had wide ranges with the earliest flowering at 35 days and the late variety at 89 days. Varieties with a difference of 20 days can be produced for seed at the same time and do not need to be isolated by distance. Flowering in spider plant, although, varied by only 4 days among lines with the earliest being the commercial variety at 26 days and the last being ML-SF-29 and UG-SF-23 at 30days. These varieties cannot be planted side by side for seed production because there is not sufficient temporal isolation. The African nightshade all flowered after two months but at varying intervals. The flowering continues over time and therefore isolation can be best achieved by distance. The local African nightshade variety is highly susceptible to bacterial wilt and no more than 3 plants per plot reached flowering stage.
The seed yields of the African nightshade are higher than Amaranthus and spiderplant. The difference in the seed yields between the highest and the lowest among the varieties of Amaranthus, spiderplant and African nightshade are 3.47 MT, 2.91MT and 2.34 MT respectively. The heavier seeded varieties would be of more commercial benefit than the lighter ones if they would also be high yielding. UG-SF-15 of spider plant had significantly fewer pods than the commercial variety but yielded as high as the commercial variety.

Seed production
Seed was produced separately for fertilizer, seed evaluation and irrigation trials that were set up by KARI and the university of Eldoret. The amounts of seed harvested and processed in 2012 was 15.992 kg. The bulk of the seed is made up of Amaranthus and African nightshade. Seed production for spider plant proved to be a challenge and resulted in the least amount (392.3 g). More spider plant has been planted in late year of 2013 for seed multiplication.

P**erformance of an improved solar dryer for processing African Indigenous Vegetables in western Kenya**

MS student Emmanuel Ayua under the supervision of Dr. Violet Mugalavai, Dr. James Simon and Dr. Stephen Weller

Solar drying is a feasible technology that can be used by vegetables farmers to prolong the shelf life of their produce. Solar drying is suitable for drying vegetables as it results in low nutrient loss compared to traditional sun drying that expose vegetables to heat for a longer time. Hence, an improved solar drying technology for vegetables could enable farmers to access external markets with dried vegetable products that have undergone minimal nutrient losses and add value to the finished product. The purpose of the study was to assess the performance of an improved solar dryer (UC Davis design) for drying vegetables in western Kenya. The study is being conducted in collaboration with Mace Foods Company of Eldoret.

Solar design

The solar dryer was designed to incorporate direct, indirect and conventional solar currents to quicken the drying process. The dryer is 30 cm above the ground with the drying tunnel sub-divided into three chambers. A transparent paper is fixed at the top of the solar dryer to allow sun rays to pass through while concentrating the heat in the drying tunnel. The design enables hot air to move into the dryer and humid air out through the chimney. Black polythene covers the lower parts of the drier to increase the rate of heat absorption.

In these experiments, ambient temperatures, temperature in the three drying chambers in the tunnel and that of a conventional Mace Foods dryer were taken every hour. The weight of the vegetables during drying was measured on an hourly basis. The final moisture content of the dried vegetables was determined.

Results.

Table 1: Weight loss of selected dried AIVs in the solar dryer

AIV name	Original weight (kg)	Final dried weight (kg)	Weight lost (kg)	Moisture content (%)	Drying test
African Nightshade	1.60	0.122	1.79	11.0	Crisp and brittle
Spider plant	5.20	0.85	4.35	10.0	Crisp and very brittle
Amaranth	0.68	0.10	0.59	10.2	brittle
African Nightshade	2.04	0.15	1.89	10.6	Brittle

Spider plant had the highest amount of weight loss compared to amaranth and nightshade. The moisture content of the vegetables ranged from 10.6% to 11%. Further, the leaves became brittle, crisp and shattered upon drying but retained good color compared to conventional drying.

In terms of temperature, the solar dryer had higher temperatures than the conventional greenhouse drying under all conditions. Time of drying was faster in the solar dryer and under sunny conditions was complete within 8-10 hours. This technique has excellent potential and will be further evaluated for drying speed and nutrient and quality composition.

Household Survey. Conducted by Dr. Martins Odendo in collaboration with Pam Obura, Naman Nyabinda and Maria Marshall.

I. Baseline Survey

A baseline survey was conducted in February 2013 in 12 of the 21 AMPATH sites in Rift Valley and Western regions Kenya. A sample of 303 households comprising members of farmers groups participating in the project and those not participating were sampled for the survey. The objective of the baseline study was to document benchmarks for assessment of project impacts along the ALV value chain

The results show that most (48%) households grew nightshade, followed by cowpea. Nightshade and amaranth were cited as the most important ALV by 93% and 65% of the households. Whilst nightshade was the most grown and preferred in the Rift valley, Amaranth and Spider plant were the most grown and preferred in Western region. This variation was attributed to cultural variation.

The key socio-economic constraints along the ALV value chain were high price of fertilizer, poor quality seed and lack of cash to buy fertilizers. The most frequently cited biophysical constraints were drought, pests and low soil fertility. These findings form an important basis for research and promotion of ALVs by targeting the preferred ALVs in each region and translating the identified constraints into opportunities. Policies should focus to ensuring farmers' access to technologies and markets.

Vendor and Consumer Choice Experiment and Survey

Marcia Croft, Ph.D. student at Purdue University under supervision of Dr. Weller and Marshall of Purdue, assisted by Dr.Pam Obura and Naman Nyabinda of FPI and Frances Einterz, a summer intern from the US.

Summary results. During the months of June-August 2013, a consumer survey was conducted with the help of Frances Einterz using a choice experiment model to determine consumer willingness to pay for quality when purchasing three key AIVs: amaranth, nightshade, and spider plant. A group of 340 consumers across 3 cities in Western Kenya in 6 different markets were surveyed. Open air markets and formal supermarkets were included, as well as markets of different size to represent the greatest diversity of consumers in Western Kenya. Consumers were asked to choose between pictures of amaranth, nightshade, and spider plant at poor, excellent, and medium qualities with assigned prices both above and below market price. Demographic information as well as customer purchasing patterns for each vegetable, preferred leaf size, and presence of a home garden was also noted. All surveys were conducted in either English or Kiswahili, depending on the preference of the consumer being interviewed.

Some important lessons were learned from preliminary data analysis. The city in which interviews were conducted made a difference in terms of consumer preferences. Nightshade was very popular in Eldoret, whereas spider plant was more common in the eastern border town of Busia; these differences are likely impacted by ethnic and cultural differences between these two places. Women were significantly more likely to choose high quality vegetables and be willing to pay a premium price for them than men, but in general both male and female consumers were very aware of the health benefits of these vegetables. Over 60% of consumers listed health benefits as their primary reason for purchasing AIVs. In general, consumers were more likely to prefer small leaves for amaranth and nightshade and rank nightshade as their favorite of these three AIVs. Customers were significantly more likely to choose the highest quality spider plant than either of the other vegetables, however, suggesting that quality in this species may be highly valued. Results indicate that if farmers are able to invest in post-harvest handling and get their produce to market quickly they stand to make a bigger profit by charging higher prices, especially for spider plant.

Vendor Survey. Marcia Croft, Ph.D. student at Purdue University under supervision of Dr. Weller and Marshall of Purdue, assisted by Dr.Pam Obura and Naman Nyabinda of FPI and Frances Einterz a summer intern from the US.

During the months of June-August 2013 a vendor survey was conducted with the help of Frances Einterz in Kakamega ,Busia and Eldoret, Kenya. Vendors from supermarkets, dedicated vegetable markets, and roadside vendors were surveyed. Vendors in Busia and Kakamega challenged some of the distinctions between the categories above. Each city differed in size, climate, culture, and preference for the different AIVs, but market chains were still strikingly similar across Western Kenya.

One striking similarity across all cities was the rigidity of gender roles across formal and informal markets. Women were in control of the informal markets, both central vegetable markets and roadside markets, while men held the positions of power in supermarkets. Even the middlemen participating in more traditional informal markets were women and though supermarkets employed both men and women, produce managers were exclusively male. In the customer surveys we carried out, we noticed significant differences between education levels of men and women, as women were far more likely than men to have only completed primary level education. These trends may not hold true over the entire Kenyan population, but it may be that poor access to education undermines women's ability to hold jobs in formal vegetable retailing. Instead, women still control the informal market sector, at least at the level of direct customer retailing.

Despite the differences, vegetable markets across Western Kenya are remarkably prevalent and well-stocked. Customers coming from urban or rural areas would have little trouble finding even the rarest AIVs in the informal markets. Those that prefer to shop in more formal markets may see their choices expanding in the future, though this is still somewhat season-dependent. Supermarket supply chains are still developing and continue to face many issues in competing with the long-standing arrangements of traditional informal markets. Though 90% of Kenyan consumers continue to buy their fresh vegetables from informal markets, this market is rapidly changing and the roles of women in vegetable retailing will have to quickly adapt with it.

Collaboration with Fintrac on AIV production in Western Kenya – Naman Nyabinda, Pam Obura and Frances Einterz, undergraduate US summer intern, and Dr. Stepehen Weller and Dr. James Simon

African Indigenous Vegetables (AIVs) are an important, available source of nutrition to populations in western Kenya. This project was a collaboration between Fintrac 's KHCP project and the Hort CRSP. Fintrac has no formal involvement with AIVs on their project so this collaboration was a great opportunity to build a stronger association between our two projects and to expand AIV production information to many smallholder farmers in western Kenya.

From June to August 2013, our focus was on spreading information on 3 three particular indigenous vegetables: amaranth, black nightshade, and spider plant, to Fintrac clients with the purpose of acquiring information about consumer preferences and improving efficient growing methods that may be used to aid in alleviating food insecurity and malnutrition faced by the population, particularly those patients of HIV/AIDS.

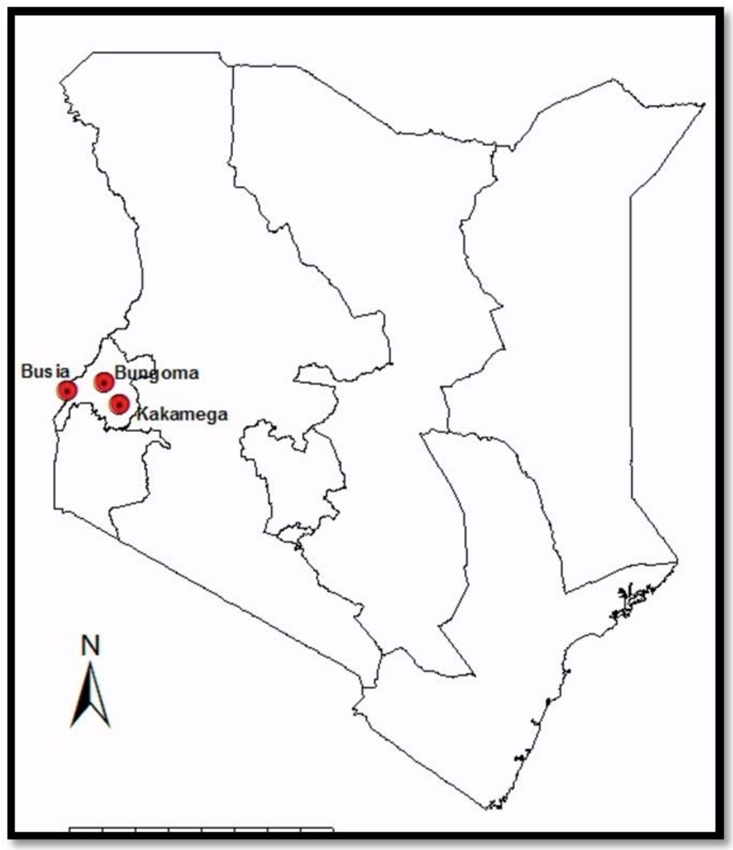
Fintrac's mission in the KHCP is to improve worldwide agricultural practices and increase food security. In this project we partnered with four groups of fifteen to twenty farmers in the western province of Kenya. Collaborating with USAID-KHCP, as well as local organizations and AMPATH employees, we designed a program to train farmers about growing the AIVs. The four sites chosen act as important demonstration of our possible impact in AIV production. The farms present us with challenges that other subsistence farmers may face growing AIVs and how specific varieties when introduced will be most successful at market and grow best in each area.

The sites chosen for this activity were: 2 in Bugoma, one in Kakamega and one in Busia. Each site was provided seeds for five varieties of amaranth, five varieties of spider plant, and five varieties of nightshade. The groups attended trainings throughout the summer about how to properly grow the vegetables and deal with any production and harvesting challenges.

The two sites based in Bungoma were originally founded with the support of CREADIS. CREADIS (Community Research in Environment and Development Initiatives) is a women-run organization founded in 2000. Its main mission is to empower communities and promote self-reliance. They are promoting root and tuber vegetables as well as bananas and have introduced new varieties into the areas where they work.

The site based in Kakamega is a youth group with the support of the Western Region Christian Community Services (WRCCS). The WRCCS was formed in 1962 as an organization devoted to agricultural extension and a supplier of farm inputs for Western Kenya. It now works in a variety of sectors including public health, water supply, and income generation; to name a few. Working with USAID-KHCP, the WRCCS has created a network of farmers in nine districts where they implement horticulture development programs including training activities.

The last site in Busia is supported by the agricultural research and extension center: Appropriate Rural Development Agriculture Program (ARDAP). ARDAP is a local NGO of Busia county whose mission is to promote sustainable farming systems through a variety of means including research, demonstration plots, and partnerships with other NGOs, government organizations and university. ARDAP provides extension services to the surrounding community with an ultimate goal of creating long-lasting food security, income, and health.



During the summer we tracked the progress of all four sites concerning the vegetables planted, and the challenges faced by each group. Multiple factors lead to differences between the four farm sites. Location obviously played a role, but so did water availability, soil type, group participation, individual literacy, and germination rates. There were a few challenges common to all four groups. A final report will be completed once the program is finished in 2014 but a preliminary summary is provided in Appendix 3c of the final report.

Tanzania Research

AIV Variety evaluation. Conducted by Nancy Kaaya of The Horticulture research Institute, Arusha, Tanzania.

This research is similar to that described for the variety and herbicide trials in Kenya and Tanzania. The experiments include the various lines of amaranth, nightshade and spider plant and their response to 3 types of fertilizer: commercial, chicken manure and no fertilizer. Results over the 2 years of these studies have been positive in that the new improved lines of the 3 AIVs from AVRDC have outperformed the local varieties in yield and quality in all seasons tested. The results from the first years of the study are presently being analyzed and a full report and paper will be prepared in year 3.

Sokoine University.

Title of Project: Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers in Kenya, Tanzania and Zambia

Dr. John Msuya and MS student Teddy Mamboleo, in collaboration with Drs. Weller and Simon.

1. Project's Progress

The project at SUA focuses on 2 objectives, namely objectives 2 and 4 of the original project. These are:

- **Objective 2:** Study existing and innovative production and postharvest technologies related to yield components and nutrient composition of officially released or pipeline AIV varieties

Activity 2.2: Evaluate nutrient composition of freshly harvested leaves of amaranth, African nightshade and spider plant

- This activity was undertaken by designing experimental plots for the three named indigenous vegetables; and procurement of research materials and equipment (1 Lap Top, 1 Deep Freezer, 4 Cool Boxes)

The AIV project activities are progressing well. We were able to collaborate with the SUA Horticulture Unit to establish an experimental plot for our activities. The experiment plots were designed for the three vegetables (2 lines each of amaranths and nightshade and 1 line of spider plant). The vegetables have done very well and have been harvested according to the research plan (at 21 days; 28 days and 35 days, which is the way they are mostly consumed). Vitamin C analyses have been completed, which require fresh samples. The remaining samples for analyses of Minerals (Fe, Zn and Se) and Anti-nutrient Factors (Oxalate, Phytate and Nitrates), which require longer procedures, have been dried and will be conducted in late 2013 and 2014.

- **Objective 4:** Build capacity of stakeholders in the AIV value chain through participatory training

Activity 4.10: Graduate training and capacity building of key research project personnel

- This activity was undertaken by identifying and recruiting 1 MSc (Human Nutrition) student at Sokoine University of Agriculture for the project activities. The student is Ms. Teddy Mamboleo registered for MSc Human Nutrition. The research proposal of the student was approved by the Department of Food Science and Technology at SUA, and therefore she is allowed to embark on the project activities starting in July of 2013.

Postharvest Market Survey – Dr. Don Lotter, St John's University in collaboration with Dr. Maria Marshall and Dr. Steve Weller.

A survey of AIV sellers and producers in the urban centers of four regions of Tanzania – Dodoma, Arusha, Morogoro, and Iringa was conducted in 2012 -2013 with an emphasis on post-harvest management of AIVs.

Retail sellers of AIVs in Tanzania are overwhelmingly female, making up 96% of sellers. The few male exceptions are often family substitutes i.e. son or nephew. Females make up the majority of AIV producers as well, at 71%, with that proportion increasing to 83% if male/female partnerships are included. 62% of the sellers had cell phones, a proportion that reflects the national average of households with cell phones. This recent grassroots technological development holds excellent potential for outreach programs in all sectors of development.

Average daily sales per retailer were US$10.12 with AIVs making up 69% of sales or $6.75. The main non-indigenous vegetables sold were Chinese cabbage, Swiss chard, and head cabbage. All of the sellers said they sell 12 months/year, 7 days/week; the mean start/end times were 7am to 6pm. Average daily weight (seller's estimate) of AIVs during the rainy season was 13.7 kg, and during the dry season was 10.7 kg, a seasonal fluctuation of 34%.

According to the respondents' recall of the 2008 price for a bundle of Amaranth, the increase in price of AIVs since then has been 50.5%. Fluctuation in AIV prices through the year was reported to be small (3.5%) (the price for the main AIV for each quarter of the past year was asked). This low fluctuation in price may be because only very basic accounting is done by both producers and sellers due to the low level of literacy. Generally, price markup is done by buying three bundles of AIV and selling two of the bundles for the same price, a markup of 33%. However, we did not determine if the weight of the bundles fluctuates during the year. On the other hand, if the price of AIVs has risen by 50% since 2008, an average of over 10% per year, there must be some changes in price during the year, perhaps by the bundle being made smaller.

Amaranth leaf was the main AIV for 83% of the retailers, with only 6% having nightshade as the main AIV and the other AIVs being the main AIV for less than 5% of sellers. When asked to give the main reason for Amaranth being the main AIV, 64% said profitability, 36% said market availability.

Regional differences emerged when sellers were asked what their #2, #3, and #4 selling AIVs were. Nightshade and squash leaf were #2 & #3 in Arusha (north) and Iringa (south), Ipomea and nightshade in Dodoma (central) were #2 and #3, and squash leaf and African eggplant in Morogoro (eastern).

The average seller of AIVs in Tanzania, as a composite, sells daily 6.1 kg Amaranth leaf, 3.7 kg nightshade, 2.6 kg squash/cucurbit leaf, 2.3 kg Ipomea leaf, 1.6. kg cassava leaf, and 1.3 kg cowpea leaf.

*Production and post-harvest***.** The average size of AIV plots is 0.66 ha in the rainy season and 0.53 ha during the dry season, with 100% of the production coming from plots with irrigation. Irrigation water deficits during the dry season account for the lower AIV crop area during that season. The predominant seed source for AIVs is packaged commercial seed purchased from stores (75% of growers), an unexpected finding. Most of the growers use a combination of manure and synthetic fertilizers for soil fertility.

Insecticide use was difficult to determine accurately, as AIVs are often included in a spray regime for neighboring beds of non-AIV crops that generally need more chemical pest control than AIVs. Profenofos, abamectin, dimethoate, lambda-cyhalothrin, deltamethrin, and endosulfan were the insecticides most commonly cited, and metalaxyl/mencozeb mix as fungicide. When asked the number of days between the last spray and harvest, producers and their partners stated on the average 10.9 days. Herbicides were not mentioned and are rarely used in small-scale vegetable production. Labor is cheap at $2-3 per day and hand weeding is therefore preferred. Only 17% of the producers knew what organic production is.

Harvest is done in the late afternoon to prepare the AIVs for early morning transport to market. On average 1.8 people harvest and carry the produce to transport, with harvest taking an average of 1.8 hours. 52% said no washing of the produce is done, while 28% used tap or drinkable water, and 20% used non-drinkable flowing water, Culling with one sellable grade was done by 31%, the rest do not grade. 83% of sellers/producers bundle the AIVs with a fiber tie, the remainder selling loose. Packaging for transport generally is nylon reinforced plastic bags approximately 1m x 0.5m, the remainder using the same type of bag inside a basket. Pre-transport storage averages 8.6 hr (overnight). Average distance to market is 11.5 km, taking 1.0 hr generally inside a passenger van (48%), hired truck with covered bed (29%), or bicycle (13%).

Producers generally sell AIVs to wholesalers by bed. A bed of one AIV, typically 1 to 1.5 m wide and 10 to 20 m long will have a widely varying price depending on supply. When supply is high, growers related that they have no choice but to sell each bed of approximately 50-100 kg of AIV for as low a price as 10,000 shillings ($6.25) for the entire bed. At other times, when heavy rains disrupt production in the market gardens of the capital city Dar-es-Salaam, wholesalers will offer up to 100,000 shillings ($62.50) for the same amount. The former scenario of surplus supply is the more common of the two, according to producers. None of the producers indicated involvement in or knowledge of any kind of cooperative for marketing.

Although cell phones have permeated Tanzanian society, an organized system for small scale growers to obtain price information has not reached the average AIV grower. Kenya is making a name for itself in Africa for its mobile phone applications, some for agriculture[1], and Tanzanian producers and sellers will likely benefit from this technology in the future. Computer and Internet use are very low in Tanzania (1.3% of the population in 2010)[2] and are unlikely in the near future to provide a channel for price information for small scale growers and sellers when mobile phone technology is so widely available. However, for growers needing information-rich and graphics-rich support such as for integrated pest management, mobile phones may not be sufficient and this may drive growth in computer and Internet use amongst growers.

Marketing. Two-thirds of the sellers rent table space in a market (67%), 20% sell from a piece of plastic laid on the ground, the remainder are mobile (basket on head alternating with sitting), verbally promoting sales. Individual selling space in markets averaged 2.6 m2, renting for $0.11 m2per day. None of the sellers were registered as a business, which is an almost totally unenforced legal requirement for small-scale sellers. A roofed structure was the environment for 56% of sellers, full sun for 21%, and full shade for 20%.

Non-refrigerated storage is available for 92% of sellers, refrigerated storage for 0%. When asked how much they would pay for each half-day (i.e. overnight) of refrigerated storage for 5 kg of produce, 70% of sellers could not answer or were not interested, 14% would pay $0.80, the remainder less. Of those who were interested, 63% and 33% wanted 1 and 2 days respectively for 5 kg of produce. At end of business day sellers have on the average 1.5 kg of produce, 62% of sellers store it and sell it the next day. The average end of business day discount is 13%.

When sellers were asked if they process any of the AIVs, 40% said they did not, 30% processed squash leaf, 17% cowpea leaf, and 10% Ipomea leaf. Slicing and sun-drying accounted for 84% of processing, boiling and sun-drying 13%, and crushing and sun-drying 3%.

Capacity Building

In Zambia, 205 farmers (23 male, 182 female) were trained on the following topics:
Land preparation, seed placement, crop establishment, weeding, scouting, pest and disease identification and management –39 farmers (9 male, 30 female) in Livingstone attended a training on how to produce quality amaranth, nightshade and spider plant products that meet the expectations of

[1] 11 October 2012 How much will technology boom change Kenya? By Gabriel Gatehouse BBC News, Nairobi. http://www.bbc.co.uk/news/world-africa-19903839

[2] Kaswamila, A. and O. Mascarenhas. 2010. Household poverty reduction by the usage of ICTs: the quantitative study from Tanzania.

the market. A similar training was held in Lusaka with the Mitengo Woman's Association where 27 women were trained during February 2013.

Irrigation management – During November, training was provided to 24 farmers (6 male, 18 female) in the use of a tensiometer when scheduling irrigation of crops. The training included practical demonstrations.

Postharvest technology – During November, training was provided to 24 farmers (6 male, 18 female) in the postharvest handling, washing and cooling of products. Food safety and hygiene also formed a key component of the training. The training was conducted in partnership with Sun International Hotel.

Harvest and postharvest handling- 35 farmers (0 male, 35 female) were trained during January on the importance of harvesting techniques and further emphasis was placed on postharvest handling, washing and cooling of products.

Marketing - 24 farmers (0 male, 24 female) were trained in marketing during February. Emphasis was placed on quality products, consistency, timeliness and types of packaging. The concept of demand and supply in relation to price was explained as well.

Production and Marketing – 30 farmers (1 male and 29 female) in Lusaka were trained on the production and marketing of AIVs during February 2013. Emphasis was placed on the correct production techniques and harvesting procedures for AIVs. The marketing of AIVs was discussed. Several enterprise development issues were discussed as well with specific reference to the importance of record keeping and traceability of food products from the farm to the market

Postharvest handling and cold storage – 27 farmers (1 male and 26 female) were trained in Lusaka in the postharvest handling and cold storage management of AIVs. Harvesting techniques and cold chain management and the associated reduction in postharvest losses were discussed.

Soil improvement - Crop rotation – 13 farmers (0 male and 13 female) were trained in crop rotation practices during April 2013. Emphasis was placed on the benefits of crop rotation and which crops to use. The use of cover crops, green manure crops and leguminous crops were promoted.

Data collection – Two male staff members responsible for the AIV trials were trained in data collection during July 2013. Emphasis was placed on timely and accurate data collection methods. The data collection templates were explained.

Land preparation – During August 2013, 9 farmers (0 male and 9 female) were trained in how to sharpen a hoe and to make most effective use of a hoe while preparing land. A garden fork, introduced by Ms. Laura Bush, was also discussed and the use thereof demonstrated.

Sowing of seeds – 8 farmers (0 male and 8 female) were trained in the correct sowing methods and rate for amaranthus, spider plant and nightshade during August 2013.

A nutrition and cooking class was also held to teach people how to best prepare AIVs. Farmer training included both class lectures and practical, hands-on exercises, and farmers also participated in field days and a seed fair. 149 farmers (75 male, 74 female) attended field days near Arusha, Tanzania, and 269 farmers and horticultural students (104 female, 165 male) attended a 2 day seed fair in Tanzania

In Kenya, 615 farmers (143 male, 472 female) were trained on AIV production and planting technology, and 276 (79 male, 197 female) were trained on crop management, pest management, harvesting, and seed saving. 50 FINTRAC collaborators also participated in both Kenya trainings.

Student training

Four US Ph.D. students (3 male, 1 female) assisted with the project (part time, hourly work). In addition, 5 Kenyan M.Sc. students (3 male, 2 female) are working on the project (full funding). 2 US undergraduates also worked as summer interns on the project.

Awards (Simon)

2013 **International Excellence Award** Recipient for 2013, School of Environmental and Biological Sciences. Rutgers, The State University of New Jersey. Based upon international development work in sub-Sahara Africa.

2012 Recipient of the **2012 Award for Scientific Excellence by a researcher in a USAID Collaborative Support Research Program**. **The Board for International Food and Agricultural Development (BIFAD), USAID**.

2012 Recipient of the **2012 Burton Kallman Scientific Award, Natural Products Association**. This award recognizes individuals who have made outstanding scientific contributions that have benefited the natural products industry.

Presentations and Publications

Simon, Weller, Marshall and Langenhoven participated in the HortCRSP annual meeting in Nairobi. Our team presented a poster at the annual HortCRSP meeting and later displayed the poster at the opening of the HortCRSP Innovation Center at KARI Theka. In addition, Weller (Purdue), Simon (Rutgers), Marshall (Purdue), Langenhoven (ASNAPP) and Yaninek (Purdue) each spoke at the HortCRSP Innovation Center at KARI Theka providing an overview to this HortCRSP project as well as the African Indigenous Vegetables project.

In addition, the project team presented on "Quality and nutritional assessment of African Indigenous Vegetables (AIVs)" at the American Council for Medicinally Active Plants 4th Annual Conference in Amherst, MA from June 2-5, 2013.

DRAFT List of Anticipated Research Papers, Technical Manuals and Other Evidence of Science-Based Research in the International HortCRSP projects.

Prepared by Weller and Simon

AIV-Purdue led, Rutgers-co-PI role (Project in 2nd and 3rd year):

1. Household survey of foods for food security and popularity including the role, if any, of AIVs in Zambia [Led by Martins/Marshal, Eldoret and Purdue with Rutgers]; *Status: data collected, paper draft in process.*
2. Household survey of foods for food security and popularity including the role, if any, of AIVs Kenya [Led by Martins/Marshal, Eldoret and Purdue with Rutgers]; *Status: data collected, paper draft in process*.
3. Postharvest handling and marketing: A case study of AIVs in Tanzania [Led by Don Lotter, with Purdue and Rutgers]. *Status: data collected, data set confirmed.*
4. Household survey of African Indigenous Vegetables in Zambia: A case study. [Led by ASNAPP and Purdue, with Rutgers]. Status: field data being collected now.
5. Marketing of AIVs in Kenya and Zambia: A comparative examination. [Led by ASNAPP and Purdue, with Rutgers]. Status: field data being collected now.
6. Seed production and quality of African Indigenous Vegetables in Kenya. [Led by KARI, with Elodret Univesity and Purdue University]. Poster presented at HortCRSP, and data set collected.
7. Impact of Fertilizer on growth and yield of Amaranth, Spiderplant and Nightshade. [Led by Eldoret University with Purdue and Rutgers]. Poster of graduate student thesis work presented at HortCRSP. Data set collected. Data needs to be confirmed.
8. Impact of Water Management and Irrigation on growth and yield of Amaranth, Spiderplant and Nightshade for continuous production. [Led by Eldoret University with Purdue and Rutgers]. Poster of graduate student thesis work presented at HortCRSP. Data set collected. Data needs to be confirmed.
9. Impact of Fertilizers on growth and yield of Amaranth, Spiderplant and Nightshade. [Led by Nancy, Tanzania with Purdue and Rutgers]. Data set collected. Data needs to be confirmed.
10. Presence and control of insect pests on Amaranth, Spiderplant and Nightshade. [Led by Eldoret University with Purdue University, involves a graduate student].
11. Integrated pest management approaches for production of Amaranth, Spiderplant and Nightshade. [Led by Eldoret University with Purdue University, involves a graduate student].

12. Nutritional characterization of dried African Indigenous Vegetables. [Led by Rutgers, in concert with Kenyan and Zambian partners, with Purdue]. Antioxidant activities, total phenols, proximate analysis completed, total carotenoids and tocopherols in process.
13. Rapid field detection method for alkaloids. [Led by Rutgers University, involves a Rutgers graduate student, with in country partners from Kenya and Zambia and Purdue]. Poster presented at HortCRSP, and data set collected. HPLC work completed, MS completed. Modifications to rapid screen underway to reduce sensitivity to link detectable limits relating to health recommendations.
14. Nutritional characterization of amaranth germplasm. [Led by Rutgers, in concert with AVRDC and Purdue, PhD graduate student from Rutgers]. Status: research in process.
15. Water use efficiency and population differences of water stress tolerance among amaranth, nightshade and spiderpplant under controlled conditions [Led by Purdue, in concert with Rutgers. Involves an MS graduate student from Purdue]. Status: research in process. Differences in tolerance to water stress identified among populations].
16. Nutrient and Phytochemical content as varied by variety, geographical location, harvest time and production systems. [This is a group effort to link production systems to nutrient and phytochemical content and is ongoing. Will not be completed till Year 3 of this project].

<u>Leveraged publications already accomplished with partnering organizations (G=Graduate student involvement):</u>

1. 2013. Ray-Yu Yang and Chris Ojiewo. African Nightshades and African Eggplants: Taxonomy, Crop Management, Utilization and Phytonutrients and Alkaloids. In: Juliani H.R., J.E. Simon and C.T. Ho (eds). African Natural Plant Products. Vol. II. American Chemical Society ACS Symposium Series, ACS Press, Washington, D.C. USA (in press). [Led by AVRDC]
2. 2013. Ray-Yu, and Sahrah Fischer, Peter M. Hanson, and J. D. H. Keatinge. Increasing Micronutrient Availability from Food in Sub-Saharan Africa with Indigenous Vegetables. In: Juliani H.R., J.E. Simon and C.T. Ho (eds). African Natural Plant Products. Vol. II. American Chemical Society ACS Symposium Series, ACS Press, Washington, D.C. USA (in press). [Led by AVRDC]
3. **Villani^{G}, T., H.R. Juliani, Q.L. Wu and J.E. Simon. *Hibiscus sabdariffa*: Phytochemistry, Quality Control and Health Properties.** In: Juliani H.R., J.E. Simon and C.T. Ho (eds). African Natural Plant Products. Vol. II. American Chemical Society ACS Symposium Series, ACS Press, Washington, D.C. USA (in press). [Led by Rutgers]

<u>Zambian HortCRSP Rutgers led, with Purdue as co-PI role (Project began Feb., 2012, about 1.3 years ago):</u>

1. Constraints to postharvest handling of fresh produce: a status of the cold chain in Zambia. [Led by Stellenbosch University and Rutgers University, with Purdue University, field data collected by ASNAPP,]. Status: field data being collected now.
2. Utilization of plastic recycable containers to improve shelf-life, reduce bruising and increase health and sanitation with fresh produce. [Led by Stellenbosch University and Rutgers University, with Postharvest Education Foundation and Purdue University, field data being collected now by ASNAPP]. Status: field data being collected now.
3. With the CoolBot and ShadeBots being built now in Livingstone, costs of their construction and utilization (energy costs and inputs costs vs. price differentials and volume of produce sold) and role to empower small-holder growers and associations will be monitored. Research has not begun- units and facilities being built in year 2.
4. A market-first science driven model to create income generating opportunities using fresh vegetable for small-holder farmers: A Case Study from Zambia [Led by ASNAPP-Zambia and Rutgers University]. Status: Manuscript outline drafted but paper not yet written.

Project Name: Creating a market niche for “food-safe” vegetables

Countries: Cambodia, Vietnam

Project Description:
The rapid economic and population expansion of Cambodian and Vietnam within the greater SE Asian region presents opportunities for impacting the livelihood of many people where horticulture remains an important undeveloped business sector supported by small farmers. Our goal is to empower small farmers (59% of whom are women) with integrated experiential education and training for sustainable vegetable production that limits postharvest losses, increases food safety, increases market access and, importantly, increases income. We have designed an innovative participatory approach to meet these goals by networking experts in horticulture production through marketing. The inclusiveness as stakeholders of farmers communes, regional universities, local governments and national communications companies in the network provides continuity needed for continuation of farmer outreach training and education beyond the lifetime of USAID HORT-CSRP funding. The successful completion of the project in Vietnam will serve as a model for implementation of the participatory action network in other, more challenging, countries like Cambodia and Laos with similar, but less developed, horticulture business sectors. Importantly, completion of this project will address essential capacity-building needs of Cambodia including an assessment of capabilities, research training, outreach development and promotion of communication between policy makers, universities and the agribusiness community. A direct impact from this project is that Cambodian and Vietnamese vegetable farmers will gain income.

Collaborators:
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Collaborators:
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Cambodia
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Borarin Bungtong, Royal University of Agriculture

Collaborators:

Thong Kong, Lyda Hok, Asikin Yoeu and Lor Lytour Royal University of Agriculture

Key Accomplishments:

- A series of Farmer Field Schools were conducted focused on topics ranging from savings groups to bio-pesticides and muskmelon and cool season crop production.
- In Hanoi, farmers who participated in the Farmer Field Schools are earning $100 more per sao (60x60 meters^2) than average, and demand for training in these new practices has increased.
- At Nong Lam University, a growers' cooperative participated in a farmer field school about postharvest handling of horticultural crops. Farmers are now trained in proper handling techniques, and the cooperative has a contract with a supermarket.
- UC Davis faculty held a workshop on grant writing for RUA faculty. Following this workshop, RUA was awarded a $100,000 grant by the World Bank to set up a Safe Vegetable Center.
- 60 farmers, traders, and local authorities in Cambodia were interviewed about production, postharvest, transport, economic and marketing needs.
- 4 one day Participatory Action Research workshops were held with farmers
- Honeydew variety trials conducted at the Royal University of Agriculture
- 15 RUA students conducted surveys and focus groups about seasonality in horticultural production activities in villages, including seasonal market changes and fluctuating availability of inputs. This information contributed to the design of a baseline survey for the savings group sub-project. The baseline survey was has been completed in 10 villages.
- One RUA team member and two RUA students were trained to become Savings for Change facilitators.
- 14 savings groups formed in Cambodia as part of the Miller sub-project
- The project's research findings were presented at a Cambodian AGRINATURA research workshop and at the Horticultural CRSP annual meeting
- 70 RUA students and 15 faculty members attended a technology training session put on by the Kasetsart Center. The training was also attended by Vietnamese project partners and private industry representatives.

Technical Narrative

Hanoi University of Agriculture

A series of Farmer Field Schools were conducted on topics ranging from savings groups to bio-pesticides and muskmelon and cool season crop production. Farmers were taught through hands-on techniques. The farmers following our production technologies are now earning $100 more profit per sao (60X60 Sq met) per growing season than average. They have also extended their crop cycles by one additional crop. They are spending less labor on their farming and have increased their acreage. This has become a huge incentive for farmers to join our project. The local government has seen the progress of the farmers and is now investing in packing facilities for the newly formed cooperative (2012). We have also garnered additional funds from the Vietnam Education Foundation, which we are using to teach an undergraduate research course to 48 students from Hanoi and HCMC. We have also written a proposal to the USAID mission in Hanoi to fund the next steps of our project, which will be an increased emphasis on marketing and business planning because the production of crops has increased significantly and the local people desire a systematic plan for future growth.

Nong Lam University- HCMC

Following the same FFS model as Hanoi, we have focused most helping one cooperative develop a system for postharvest handling of horticulture crops. The net result is a packinghouse and people trained in proper handling of vegetables. We have also conducted research and trainings on how to link production techniques with postharvest handling. This has led to the cooperative to garner contracts with supermarkets and increased profits for member farmers. Additionally, the community development group has developed a savings programs for immigrant farmers from the north. This has been highly successful and profits from the loans have been used to develop a revolving capital fund for poor farmers. In terms of research, efforts have studies have mainly focused on composting and on energy use reductions as a result of the Cool Bot technology. We worked with the local cooperative to redesign a cool room with proper insulation and integrated the Cool Bot. We are collecting pre-post data on energy use.

Cambodia- RUA

The building of local capacity to manage an on-going project has been a priority for the UC Davis team in Cambodia. We have invested a lot of time in working with the RUA team so that they can manage this interdisciplinary project. As a result of these efforts, RUA hosted a regional workshop for 130 people from 4 countries. Photo-voice-based evaluations showed a high level of satisfaction with the workshop.

The Cambodian team membership has been in a constant flux because young faculty who speak English are offered MS and PhD degree programs and leave the project. Thus far, 3 of the 5 people from the Cambodian team have been replaced. Nonetheless, we were successful in garnering a $100,000 grant from the World Bank for a Safe Vegetable Center located on the RUA campus. The Center will train RUA faculty and students about safe vegetable production.

Research projects on mulching were conducted by the Production/Environmental Monitoring team. These met with limited success because of a lack of expertise in horticulture. Realizing that we had little expertise in horticulture (there is not a horticulture department at RUA), we hired a recent Cambodian graduate from HUA to oversee new crop trials. The addition of this person has helped the RUA team begin new crop trials on honeydew melon production that mirrors our success in Hanoi. The trials are ongoing, and we are having some challenges with pests. Our hope is to set up a public/private partnership with local companies and RUA, which will benefit local farmers in a similar way as the Hanoi-based project.

Sub-Award (Miller)

The sub-project *Investigating Community Investment in Horticultural Technologies: A Demand Study* was added on to the existing HARE-NETWORK project as a complimentary set of activities. This project seeks to strengthen the groups of farmers engaged in the farmer field schools by helping them form savings groups. The project team will then measure how the groups adopt and adapt Hort CRSP technologies, and they will also assess the impact of the technologies on group members' farming activities and incomes. Frederik Sagemuller and Neda Yousefian arrived in Cambodia in August 2012 to implement this sub-project. Their first tasks included meeting with NGOs and creating partnerships to achieve the project's goals, identifying a project location and creating a team of RUA students to assist with surveys and training activities.

NGO Partnerships

In August of 2012 we met with the East Asia Regional Director of Oxfam America (OA), Brian Lund, to share our project idea of using their Savings for Change model to form farmer savings groups. We went on a site visit with OA's Savings for Change staff to observe savings groups in Kampot province. The outcome of several meetings was a MOU with OA where they agreed to train our staff to become facilitators for savings groups. We hired an Oxfam-trained facilitator to begin forming savings groups while our staff became more familiar with the process.

We also met with the Agricultural Director of IDE Cambodia, Philip Charlesworth, in August of 2012 to discuss our project and learn about their agriculture activities. They have a training program that teaches farmers about different production practices and technologies and prepares them to become input suppliers to other farmers. At present we are working to connect farmers in our project villages with IDE's services, and we also hope to work with IDE to establish an internship program for RUA students.

We also met with Dennis Lesnik, the Chief of Party for Fintrac in Cambodia, to discuss our research goals and desired activities. Fintrac is working in four target provinces and Kandal province, where our project is located, is not among them. However we were able to have several meetings with the microfinance team and organized a meeting and field visit between Fintrac and Oxfam America to explore the possibility of adding savings groups to the financial services offered by Fintrac.

Village-based Data Collection
In September we identified Sa'ang District as our project location. It is located in Kandal province, roughly 1 hour south of Phnom Penh. This area is a major vegetable-producing region that supplies Phnom Penh markets. We met with commune leaders and presented our ideas of savings groups and farmer education. We asked them to identify the villages that have the most vegetable production and to provide us with the contact information for village leaders. We then met with village leaders and acquired more detailed information about the number of farmers in the village and asked for their help in inviting farmers to focus group discussions.

Focus group discussions were conducted at the end of October 2012 with farmers in 12 villages. A pair of trained RUA students led the discussions. The format for the focus group discussion was around the seasonal calendar. Farmers were asked about their production activities, pest and disease pressure, market fluctuations and availability/quality of inputs as they relate to the seasons. The responses from the focus group discussions were used to design the baseline survey and also informed field trials.

The baseline survey was designed in December and January of 2013. Fifteen RUA students were trained to conduct the survey and implementation began the last week of February in the control villages. In the 6 control villages 250 farmer households were interviewed. Of the treatment villages, 4 have been surveyed and 2 remain. Our approach is to wait until savings groups are formed in the treatment villages so that we are sure to survey group members. The baseline survey will be completed by the end of November 2013. We expect to have the data entered and analyzed by February 2014.

Savings Groups
In November a MOU was signed with Oxfam America to use the Savings for Change (SfC) model to form our farmer savings groups. In mid-February we hired a SfC facilitator, Sophea Korng, who was trained by OA and has 3 years of previous experience forming savings groups for a local NGO. She immediately began conducting household surveys and forming savings groups made up mainly of farmers. She is supervised by the PGRs and has two RUA students working as her assistants. She also works closely with the RUA team member, Thort Chuong, who is responsible for connecting the savings groups with the farmer field school trainings. In July 2013, OA trained Thort and the two students to become SfC facilitators. They are responsible for data collection, monitoring the current groups and forming new ones as the need arises. As of October 1, 2013 there are 14 groups formed. The next steps for the

savings groups are to introduce and demonstrate the Hort CRSP technologies and to conduct bookkeeping trainings using materials from the FAO and Freedom from Hunger.

We are members of the Access 2 Finance forum, which is a group comprised of both international and local NGOs who work specifically in savings-led microfinance. We also attend bi-monthly meetings hosted by OA to discuss activities and future plans as well as to network with other organizations that are also implementing SfC.

KU Training

In July we invited members of the Horticulture CRSP Center of Innovation located at Kasetsart University in Thailand to come to RUA to conduct a two-day training on the following Hort CRSP technologies: solar drying, soil solarization, solar-powered drip irrigation, bio-nets, drying beads and the CoolBot. This training occurred directly after the annual meeting of the HARE-NET project so that project members from the Hanoi University of Agriculture and Nom Long University could also learn about the technologies. In addition to the Vietnamese teams, over 70 RUA students and 15 RUA faculty members attended this training along with Vietnamese project team members and private industry representatives.

The technologies were set up at various locations on the RUA campus and for each technology there was a technical session as well as a practical, hands-on session. Fact sheets and more detailed instructional documents were distributed to all participants. These documents will be translated into Khmer and shared with farmers during farmer field school meetings.

Field Trials

In order to identify good agricultural practices that address the needs of farmers in our project location, we have conducted three field trials on campus and are designing two more to be installed by the end of December. These trials are informed by the focus groups' discussions as well as field observations of production problems.

Our first field trial on the effectiveness of protective nets to reduce pest damage on Chinese kale was conducted on campus in April 2013. The trial measured both pest damage and plant growth of the Chinese kale grown under a net with Chinese kale grown in the open. It was done in collaboration with a RUA graduate student as part of his thesis research.

The second field trial, conducted in May 2013, was to address the overuse of pesticides, especially on leafy green crops. Leafy green vegetables have high market value and thus are among the most widely produced crops in the project area. The year-round production of leafy greens without any significant rotation, combined with the 3 to 4 times per week application of pesticide cocktails, has resulted in a high-density pest population and a dearth of beneficial insects. The striped flea beetle is considered the most important pest for these crops as it causes the most physical damage to the leaves. We consulted experts from the AVRDC, UC Davis and the IPM CRSP about the striped flea beetle and the response was that farmers must implement a crop rotation and can use Chinese mustard as a trap crop. Since our farmers are growing Chinese mustard as the main crop we focused our attention on crop rotation and testing alternatives to chemical pesticides.

Our trial was designed to test the effectiveness of a biopesticide on Chinese mustard. The biopesticide recipe came from the Hanoi University of Agriculture and contains hot peppers, garlic, rice wine, molasses and effective microorganisms. The results from this trial are forthcoming and the trial will be repeated during the dry season.

In August 2013 we began a third field trial on the RUA campus to test different varieties of muskmelon and to identify best growing practices for this region of Cambodia. The muskmelon is a high value crop in Cambodia and we believe it can help generate income for project farmers who add it into their annual rotation. The trial is testing 5 varieties of muskmelon (2 from Vietnam, 2 from Cambodia and 1 from Thailand). A second factor in the trial is comparing the growth of melons on a trellis to those on the ground. Plastic mulch is used in all treatments, as are pheromone traps and the application of organic fertilizers. The interdisciplinary HARE-NET project team is conducting research on different production, postharvest, marketing practices, as well as examining the economics of the different varieties and systems. A second round of this trial will begin in December to compare results between the rainy and dry seasons.

Capacity Building

Farmer Field Schools: Farmer Field Schools were held at 2 locations in Vietnam. No data was provided on the number of participants.

Kasetsart Training: In July, trainers from the Horticulture CRSP Regional Center of Innovation at Kasetsart University (Thailand) came to RUA (Cambodia) to train project team members, RUA students and RUA faculty on low-cost, easily adapted technologies such as solar drying, soil solarization, solar-powered, drip irrigation, drying beads, and more. The training was attended by 16 Vietnamese project team members and private industry representatives (10 men, 6 women) and 120 Cambodians (80 men, 40 women), the majority of whom were students or faculty at RUA.

Student training:

The project has fully or partially funded 37 (15 men, 22 women) bachelor's and master's degree students at Nong Lam University, Hanoi University of Agriculture, and the University of Agriculture and Forestry (all in Vietnam). In addition, 15 students from the Royal University of Agriculture (Cambodia) were trained to conduct village surveys. One RUA team member and two RUA students were trained to become Savings for Change facilitators

Presentations and Publications

Two papers from the project with Hanoi University of Agriculture are currently under review in refereed journals.

Four papers are in preparation to share the results of research conducted in HCMC.

Conferences

In January we presented our proposed research at The Cambodian AGRINATURA Research Workshop on Integrated Agriculture and Natural Resource Management for Sustainable Development. We had an audience of 60 people including RUA students and faculty and representatives from various local and international organizations.

In May Frederik Sagemuller presented our research at the annual Horticulture CRSP conference in Nairobi, Kenya.

Horticulture CRSP project technical reports
Theme: Nutrition
Project 1: Sustainable Technology for Orange and Purple Sweetpotato (STOPS)in Ghana led by Eunice Bonsi of Tuskegee University

Bonsi Tech Report

Project Name: Strengthening the value chain for orange- and purple-fleshed sweet potatoes

Project Description:
In Ghana, the prevalence of vitamin A deficiency is high among children and pregnant women. Vitamin A deficiency (VAD) affects 72% of the country's children under five population and contributes to one out of three of all child deaths between the ages of 6 to 59 months. The projected number of childhood deaths attributed to Vitamin A deficiency will be 104,300 between 2005 and 2014.

Sweet potato is considered an excellent food security crop in sub-Saharan Africa. Although high in carbohydrates, white sweet potatoes mostly consumed are very low in beta-carotene, precursor to vitamin A. Widespread production and consumption of the vitamin A-rich orange and purple sweet potatoes in Ghana still remains limited due to lack of awareness, limited availability of clean-planting materials and limited inclusion in the diet for diversity.

Using the gap and decision analysis tools, **"The Sustainable Technologies for Orange and Purple Sweet potatoes (STOPS)" project** proposes to strengthen the value chain in three sweet potato growing regions in Ghana to improve food security, agricultural productivity and economic value. This aligns with the themes and related strategic emphasis of the Hort CRSP and USAID Feed the Future Initiatives in Ghana as a focus country.

Throughout the chain analysis, gender and the status of children will be given elevated consideration to ensure the participation and benefit to women and children from project services and outcomes. By working with most of the actors along the value chain, this research has the potential to enhance the economic opportunities especially among resource-poor sections of the rural population.

Collaborators:
USA
Dr. Eunice Bonsi, Dr. Conrad Bonsi, Dr. Desmond Mortley, Dr. Robert Zabawa, and Dr. Prosper Doamekpor; Tuskegee University

Dr. Leland Glenna, Dr. Thomas Gill, Dr. Janelle Larson, and Dr. Sjoerd Duiker; Pennsylvania State University

Ghana (no individuals identifies in proposal)
Crop Research Institute
Savannah Agriculture Research Institute (SARI)
Ministry of Food and Agriculture
University of Ghana
Food Research Institute
University for Development Studies
Selasie Farms and Groceries
Adonokope Farmers Association

Key Accomplishments:
- Established a clean sweet potato vine multiplication site at the SARI research site
- Established clean vine multiples sites at two research facilities in the Northern and Upper East

Regions in Ghana

- Selected farmers to demonstrate production of clean sweet potato vines and serve as clean vine distributors
- Conducted focus groups on orange and purple sweet potato palatability and preferences with local NGOs and schools
- Established orange and purple sweet potato demonstration gardens at a junior high school, a high school, and NGO sites. Gardeners at the NGO sites expanded the garden by 100% on their own initiative
- Distributed handouts on orange and purple sweet potatoes
- With SARI and UDS, conducted an analysis on products containing orange and purple sweet potatoes currently available in Ghana
- Developed a partnership with 4H Ghana to help promote orange and purple sweet potatoes to youth
- Developed new technologies for sweet potato processing
- Promoted the inclusion of orange and purple sweet potatoes in traditional recipes, some of which were served at the SARI cafeteria
- The Penn State and SARI teams surveyed 540 households in three regions in Ghana to gather baseline information about sweet potato production, the sweet potato value chain, and household food security and demographics
- Focus groups, key informant interviews, and market were held to validate the survey data
- Local bakers are now using locally-grown orange fleshed sweet potato puree to make bread
- Dr. Eunice Bonsi was shortlisted for a "Change Maker for Global Nutrition" Award

Technical Narrative

Tuskegee University has made significant gains in the major objectives of the STOPS Project, including establishing a research model for orange and purple sweet potato dissemination and adoption. Clean vine multiplication sites were established at the SARI research farm and at two research facilities in the Northern and Upper East Regions. In addition, the project selected and trained farmers to demonstrate clean vine multiplication to their communities. These farmers are also acting as local distributors of clean vines.

In addition, the project has developed important partnerships with local schools, youth groups, and NGOs. The school and NGO groups are helping with sweet potato taste evaluations and participating in educational focus groups, and 4H Ghana is helping to promote orange and purple sweet potatoes. In addition, the project team worked with a junior high school, a high school, and an NGO to establish orange and purple-fleshed sweet potato demonstration gardens. The NGO garden was so successful that the participants decided to expand the area by 100% on their own initiative.

In country partners Savannah Agriculture Research Institute (SARI) and the University for Development Studies (UDS) have developed, tested, and promoted products made of orange and purple-fleshed sweet potatoes. SARI has incorporated orange and purple sweet potato roots and leaves in menu items at its cafeteria, and both organizations have promoted the use of orange sweet potatoes in recipes that traditionally use white sweet potatoes. In addition, the project team developed new technologies for sweet potato processing, specifically related to making puree and drying raw chips.

This project year, the Pennsylvania State University (PSU) team worked closely with the socio-economic analysis team at SARI in northern Ghana. The work focused on conducting baseline analyses of sweet potato producers to characterize the sweet potato production systems in three regions of Northern Ghana: Northern, Upper West and Upper East. They administered a comprehensive household survey to 540 households across the three focus regions. This survey captured data on the production systems of these households, their involvement in and awareness of sweet potato production and issues surrounding the sweet potato value chain. The survey also captured data on the food security status of households, as well as various demographic data. Survey data was validated through focus group discussions and informal interviews with producers. These interviews also allowed the project team to explore critical issues that arose in the survey responses in more depth.

Three Penn State partners, Dr. Tom Gill, Dr. Leland Glenna and Mr. Vincent (Vinny) Ricciardi (MS student), visited the project in the first week of October 2012. The purpose of this trip was to meet with our new collaborators at SARI, to develop the household survey tool and to conduct initial field visits to sweet potato producers and potential survey sites. The team also visited with a variety of other stakeholders and made a briefing visit to the USAID mission in Accra.

In June and July 2013, two PSU team members traveled to Ghana to follow-up with the SARI socioeconomic team and conduct some validation of the survey data. Vinny Ricciardi was in Ghana for most of the summer working on sweet potato network analysis for his MS thesis, and he also worked for 3 weeks alongside the SARI survey team to conduct focus groups, key-informant interviews and market visits to validate the data. Dr. Janelle Larson (PSU associate professor of agricultural economics) joined Vinny for 4 days in early July to assist with project activities.

SARI's field implementation team totaled 24 persons including 16 enumerators, 3 supervisors and 5 data entry clerks. Survey data was cleaned and compiled into summary table and statistics, and the final report and all data in SPSS (statistical software) was received by SARI in September 2013.

Capacity Building

(Missing short-term training report)

The project fully funded a Masters student at the University of Development studies in Ghana. It also provided partial funding to a Masters student and a PhD student from Penn State.

Presentations and Publications

The project developed several factsheets about orange and purple-fleshed sweet potatoes, which were distributed in Ghana. Formal publications are planned for the final year of the project.

Horticulture CRSP project technical reports
Theme: Enabling environment
Project 1: Increasing the Capacity of Smallholder Farmers to Produce and Market Vegetable Crops in the Democratic Republic of Congo and Uganda led by Kate Scow of University of California, Davis
Project 2: Innovative Energy Solutions in Horticulture led by James Thompson of University of California, Davis
Project 3: UC Davis D-Lab & Horticulture CRSP Innovation Centers: Providing support & capacity building to bring appropriate technologies to market in Honduras and Thailand led by Kurt Kornbluth of University of California, Davis

Project Name: Developing a Participatory Extension Model to Enhance Smallholder Production and Marketing
Countries: Democratic Republic of Congo, Uganda
Project Description:
Although the growing market for horticultural products in Uganda offers an opportunity for smallholder farmers to improve their income, their access to these markets is still limited. This project will develop a participatory extension model to rapidly improve smallholder linkages to horticultural markets, which will be achieved by merging and supplementing two agricultural development models - Farmer Field Schools (FFS) with the Participatory Market Chain Approach (PMCA). We will work with farmer groups established in our pilot project in Nkokonjeru, Uganda and evaluate the potential of our adapted FFS methodology to a pilot community in the Democratic Republic of Congo. Specific objectives are to strengthen farmer groups' capacity to produce indigenous leafy green vegetables and tomatoes for the market and improve farmers' ability to use their farm as an income generating asset. Research in small plots and on farmers' fields of economically appropriate soil fertility management technologies, including micro-dosing, improved varieties, irrigation, and safe pesticide use, will help identify ways to increase vegetable yields and quality. Curriculum enhancement with a local university (Uganda Christian) and Uganda's primary agricultural university (Makerere), as well as with governmental and NGO agricultural extension, will strengthen the region's capacity to carry out and sustain research and extension activities for horticultural crops.

Collaborators:
US
Principal Investigator:
Kate Scow, UC Davis
Co-Principal Investigators:
Johan Six, Mark Van Horn and Heidi Ballard, UC Davis
Collaborators
Stephen Boucher, UC Davis
Uganda
Collaborators:
Edith Naggenda and Ignitius Bwoogi, Rural Agency for Sustainable Development
Michael Masanza; Uganda Christian University
Beatrice Akello and Peter Lusembo, NARO-MUZARDI
Harriet Nsubuga Mpanga, Agribusiness Initiative Trust, Inc.
Prossy Isubikalu, Makerere University
Dennis Yiga, Mukono District Local Government
Democratic Republic of Congo
Karel Van Laer, Scheut Tshilomba

Key Accomplishments:
- Conducted Rapid Market Appraisal of value chains for indigenous leafy greens at major local markets, presented it to local market chain actors
- Market actors discussed ways to strengthen the nakati market chain, and formed three focus groups to explore seed production and processing, fresh production and marketing, and processed nakati products
- The seed production group, Nkokonjeru Seed Farmer Group, joined a farmers group, went through seed production training, and produced 250 kg of seed (mainly nakati). They have

gotten contracts to produce 900kg of seed next year, and are providing seeds to NGOs and the government.

- PMCA final event held. 103 people attended, including representatives of national and international agricultural organizations. New AIV products were displayed, MUZARDI shared agricultural information about AIVs, and farmers and agricultural input suppliers had the opportunity to share their knowledge and experience.
- "Farmer's Basket", a popular Ugandan TV program, did a feature on two female AIV farmers' experience with PMCA.
- Five students (2 undergraduate, 3 graduate) are involved in conducting research for the project
- 280 participating farmers from all treatment groups were surveyed; results are currently being analyzed
- 6 Ugandan scientists and technicians have adopted participatory methods in their own projects as a result of the Hort CRSP team's work with a Ugandan ZARDI (Zonal Agriculture Research and Development Institute).
- Factsheets on AIV production and marketing created and distributed, brochure on PMCA innovations created
- Curricula developed for undergraduate classes on "Participatory Methods" and "Agricultural Extension"'
- 39 farmer groups drafted constitutions, 39 farmer leaders elected to positions
- 20 farmer groups and 29 individuals were interviewed on market interactions
- a Rapid Market Appraisal for indigenous leafy greens was conducted

Technical Narrative

PMCA Activities

The Participatory Market Chain Approach (PMCA) is a methodology that brings market chain actors together during a series of participatory meetings intended to open up new communication lines and build trust among market chain actors. Phase I of the PMCA began with a Rapid Market Appraisal that assessed supply and demand chains for indigenous leafy greens in major markets within the region. The appraisal was presented to representative market chain actors at the PMCA kick-off event. In Phase II, market actors discussed and identified promising opportunities to strengthen the nakati market chain. Three thematic groups were formed to explore 1) seed production and processing, 2) fresh nakati production and marketing, and 3) processed nakati products. During Phase III of the PMCA, market actors pursued the thematic group of most interest to them.

PMCA Final Event

A final event was held on 16^{th} May, 2013 to report on the progress of each group. The event also served as a time to launch innovations developed during Phase III to attending researchers, developmental partners and the general public.

The major outputs of the event included the following:

1. *Launching of market innovations*: vegetable market innovations were presented to the event attendees. These included processed nakati seed, nakati peanut butter, dried nakati powder, and nakati *baghia*, which is a common street snack now with dried nakati added.
2. *Exhibition of innovations launched*: an exhibition was held in which the above market chain innovations were exhibited to the general public. Two seed companies, East African Seeds Co.

and Victoria Seeds, were invited to exhibit their seed and agro-chemical products. The companies gave priority to seeds of indigenous vegetables, such as *Bbugga* and *Jjobyo*. Farmers who participated in PMCA events brought fresh leafy green vegetables to display and sell in a farmers' market.

3. *Information materials were disseminated to participants:* MUZARDI developed informational materials on nakati seed production, processing protocol for nakati, and a briefing on the importance of green vegetables and the project goals and outputs, including a poem on greens written by project farmers, to distribute during the event. Three hundred and thirty brochures were distributed and the rest reserved for the Institute Information Centre.
4. *Experience sharing*: during plenary discussions, at least five market chain actors had a chance to share the experiences they had gone through in the PMCA process. Participants also heard from MUZARDI staff summarizing PMCA activities and outputs.

The event was attended by a total of 103 people who included farmers, processors, traders and students as well as officials from research, extension, the donor community and the private sector. Organizations represented included the National Crops Resources Research Institute (NaCRRI), National Semi-arid Resources Research Institute (NaSARRI), National Agricultural Advisory Services (NAADS), International Potato Centre (CIP), Uganda National Farmers' Federation (UNFFE), East African Seeds Co., Simlaw Seeds Co., and Victoria Seeds Co. Local government officials from Buikwe and Mukono Districts were also present.

While covering the PMCA Final Event, the producer of Uganda Broadcast Company (UBC) was motivated to further pursue coverage of the PMCA by devoting one episode of a popular TV program "*Farmer's Basket*" to the PMCA program. The episode chronicled two women farmers' experiences with the PMCA and as indigenous vegetable producers. An RASD staff member was also interviewed on his experience as the lead farmer of the new network of seed producers.

The most significant activity resulting from the PMCA is the formation of a registered seed production group, the *Nkokonjeru Seed Farmer Group*. This new organization of farmers has begun commercial seed production and is now contracting with national and regional seed companies to produce seeds of indigenous vegetables. So far, the group has produced and sold over 250kg of seed, primarily nakati (*Solanam Aethiopicum*). The farmers of this group were provided training by MUZARDI in seed production best management and post-harvest practices. After an initial small-scale contract with Simlaw Seed Co., this group has now obtained contracts to produce up to 900 kg of seed in the next year. The average price per kg of seed equates to roughly $7.60, meaning these sales could contribute over $8,800 to these producers over the next year. The group intends to bring in new producers to meet the demand for seed and is beginning to diversify into other indigenous crops, such as *ntula* or African eggplant, and various Amaranthus species. The PMCA team supported the group to launch a branded seed package for sale at local seed shops. These packages will serve as an alternative marketing route to the seed company contracts if need be. Additionally, the group has been working to bolster its reputation locally by selling seed to NGOs and the local government.

<u>Evaluation of FFS-PMCA Process</u>

An endline survey was conducted with 280 farmers from all four treatment groups as the last of a 2-round panel survey. During the survey, Hort CRSP trained undergraduate students from 3 universities (UCU, Kyambogo, Makerere Univ. Business School), and 6 agriculture professionals (one leading an NGO, one research assistant in the National Agricultural Research Organization, two research assistants for Hort CRSP, one gender officer for the Mukono District Farmers Association, and one staff member for a Mukono-based NGO). The results of this endline have been entered and are currently under analysis for program evaluation and broader agricultural extension research publications.

Capacity Building

<u>Student Training</u>

Two undergraduate women from Uganda Christian University completed their internship with Hort CRSP. These interns participated in a broad range of activities, including assisting in on-farm trials on ISFM, participating in and documenting the PMCA process, conducting open-ended interviews, and participating as enumerators in a household survey. The interns also conducted an exploratory research trial on the effect of incorporating products of charcoal production (biochar) into the soil to investigate residual effects. This trial resulted in the project team developing a larger trial both on station at MUZARDI and on farm.

In addition, 11 people (7 men, 4 women) from RASD, MUZARDI, and Uganda Christian University were trained on how on how to conduct surveys, and they surveyed participants in order to evaluate the project. They earned certificates as the result of their completion of enumerator training.

Overall, 8 Uganda Christian University undergraduates (2 male, 6 female) participated in the project: either as survey enumerators, special project students, or interns.

- <u>UC Davis - PhD Research</u>

Lauren Pincus is in the process of collecting her dissertation data in Uganda. She is based in Nkokonjeru, Uganda. In June 2013 she completed the first field season for her two research projects. Her field trial is investigating the effect of organic and inorganic fertility sources across soil types. She harvested from thirty-three plots, each located on an individual farmer's plot of land, and is waiting to process the samples to determine dry weight and nutrient content. Her second research project looks at the internal and external characteristics important in farmer adoption of inorganic fertilizer. For this research she has organized farmer groups in four villages and is holding educational sessions involving hands-on and classroom education on soil fertility management. As of September 2013 she has planted plots for the second season of her on-farm trial and is continuing to meet with farmer groups and gather social science data into their attitudes related to soil and soil fertility.

2. <u>Makerere University Masters' Research</u>

William Sekamate has finished two seasons of on-station trials comparing different combinations of organic and inorganic fertilizers on Nakati yield (harvestable biomass) and quality (leaf size, height). He has also completed eight on-farm trials and farmer evaluations of the most promising combination of organic and inorganic fertilizers. William is now working with project staff on a trial investigating the common local practice of producing ILVs where charcoal has been burnt. The trial is looking into the residual effects of charcoal production, ash, and charcoal dust. These treatments are combined with fertilizers and compared with agricultural lime and biochar to see if there are common liming effects or interactions with fertilizers. His thesis is in the process of final review and he will graduate in the next few months.

Nassib Mugwanya has completed in coursework for his Masters, as well as research activities documenting the FFS and PMCA process. His study explored ways in which linking two participatory approaches influences how farmers produce and market indigenous leafy vegetables. Qualitative fieldwork reveals notable changes in both production and marketing practices. In production, changes were evident in major crops grown, relative increase in land size allocation, and use of modern agronomic practices. In marketing, changes were in major crops grown for sale, and relative increase in farmers' awareness of market standards for indigenous leafy vegetables. He is in the process of submitting his thesis for final review.

Collaborations with Host Country Research Teams

Hort CRSP staff have worked closely with a zonal research and development institute (ZARDI) in the eastern region of Uganda to disseminate FFS practical knowledge. The collaborating ZARDI is interested in nesting a FFS approach within their existing multi-stakeholder innovation platform (MSIP) methodology. Uganda's Ministry of Agriculture has a policy priority to use MSIPs at all levels in the research to extension pipeline. Hort CRSP and ZARDI staff have consulted to encourage integration of participatory extension into the ZARDI program. As a result, six scientists and/or technicians in the eastern zone ZARDI have started using participatory techniques to different degrees and have reported the benefits to project staff. PI Scow visited the ZARDI institute to discuss the current status of their research program and the integration of MSIP and FFS methodologies with the director and his staff.

In addition, 10 extension agents were trained as FFS facilitators, and received certificates.

Farmer Training

460 AIV producers (150 men, 310 women) in 24 farmers' groups received training through this project. 10 of these groups were specifically trained in seed production. 20 lead farmers were trained in participatory production, marketing, and farmer group organization, and received certificates. The lead farmers attended workshops on agronomic practices and seed sources, budgeting and farmer group project planning, and participatory monitoring and evaluation.

Presentations and Publications

None during this reporting period

Thompson Reid Tech Report

Developing energy solutions for horticultural production

Project Description:

Among the most promising disruptive technologies for application to horticulture are those that address the uses of energy in the production, marketing, and processing of horticultural crops. We propose to test a range of sustainable energy solutions, particularly focused on photovoltaics, and to deploy the most promising at the HortCRSP Centers of Innovation. Technologies that will be discussed for possible testing include:

- D.C. split air conditioner/CoolBot for a solar-powered cool room
- In-village solar panel construction to reduce the cost of photovoltaic supply
- Inexpensive photovoltaic pumping based on R.V. water pumps
- Adsorption refrigeration using Zeolite beads
- High intensity LEDS for a solar-powered germination cabinet
- Vacuum-sealed straw bales for building inexpensive insulated rooms
- Aerogel panels for high-quality insulation
- Peltier-effect cooling for small-scale transport
- Low-cost air suspension for small-scale transport
- Simple solar dryer for fruits, vegetables, and grains
- Facilitated solarization for weed and soil-borne disease control

Collaborators:

USA:
Principal Investigator:
James Thompson, UC Davis

Collaborator:
Michael Reid, UC Davis

Key Accomplishments:

- Derived equations estimating how long it would take Peltier Blocks powered by a solar panel to cool 100kg of potatoes to 0 degrees C.
- Tested photovoltaic panels and gas generators as possible alternative energy sources for cooling in areas with unreliable electricity in Bangladesh.
- Developed a model predicting energy demand for cooling given different room sizes and types. This will let people know how much solar energy is required and when it is required, so they can make an informed decision about using solar power.
- Calculated cost estimates for several potential solar-powered cooling set-ups (full time cooling, day-time only cooling).
- Tested innovative insulation for coolrooms, including Polyurethane Structural Insulated Panels (SIPs). The project plans to test additional, lower-cost insulation options in the future.
- Commissioned the construction of a small, bike-pulled trailer that can carry a commercial solar or battery-powered cooler/ice chest.
- Tested the amount of time it took for a 10kg bag of potatoes to cool in the cooler, and then tested how long the potatoes retained the cool temperature once the power was removed
- The Thompson-Reid dryer was tested in Pakistan and Uzbekistan.

- The project is currently testing desiccants that could be used to help dry grains and pulses for storage in humid climates

Technical Narrative

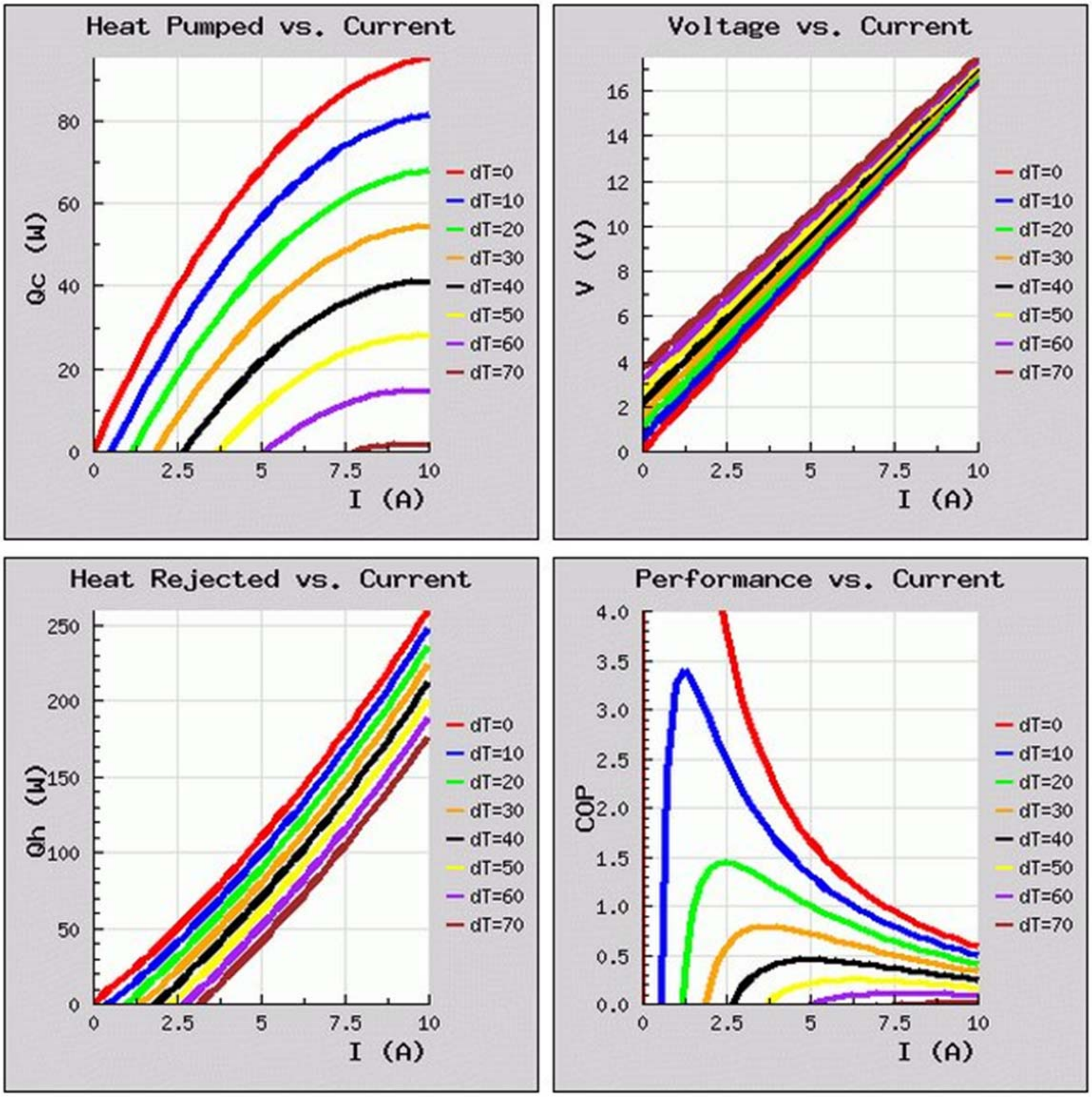
During this reporting period, our major focus has been on peltier block cooling, cooling in communities where grid electricity is unavailable or unreliable, small-scale transportation, modeling coolroom performance, and developing strategies and tools for the dry chain.

Peltier block cooling:

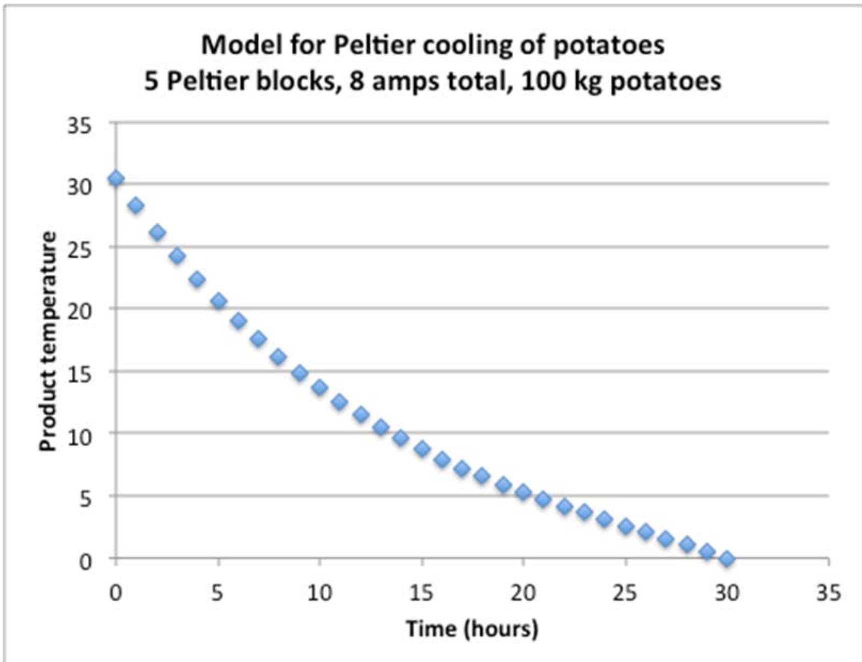
The peltier block is a semi-conductor cooling device based on the Peltier principle in which a current flowing between two junctions of dissimilar conductors results in the heating of one junction, and cooling of the other. These devices have been used for many years in specialized cooling applications such as refrigerated microscope stages and the controlled temperature blocks of PCR machines. More recently, they have been applied to cooling of high-powered CPUs in computers. Their wider use has resulted in a remarkable increase in cooling capacity and reduction in price. We purchased blocks capable of 300 W cooling (about 1000 BTU/h) for less than $20. Despite their many other advantages – including lack of any moving parts, small size & compatibility with any DC source (including solar), Peltier devices are seldom employed where a traditional Carnot cyle-based refrigeration system is applicable, because of the difference in efficiency between Peltier and Carnot cycle heat pumps. This difference is a function of resistive heating in the conductors of the Peltier block. Heat pumping increases linearly with increasing electrical current, but resistive heating increases as the square of the current. This is what limits the total cooling of any Peltier device. In looking at the published graphs of current, cooling, and coefficient of performance (watts of cooling per watts of input energy) it seemed obvious that improved COP could be achieved simply by under-driving the Peltier block. The graph below, for example, shows the typical relationship between current and cooling for a 100W Peltier block at a range of temperatures between the cool and hot faces of the block. As the current rises, so does cooling, until it reaches a plateau where the rate of cooling equals the rate of resistive heating.

The graphs of COP versus current for the same block and temperature differences (lower right panel) demonstrate a pronounced peak in COP at about ¼ of the maximum recommended current. Given the low cost of Peltier devices, it seemed that using more blocks, and running them at lower currents, would be an effective way of providing a higher COP, thus overcoming one of the cited deficiencies of Peltier blocks for cooling horticultural products.

One of the interesting features of these equations is the strong effect of temperature difference on cooling rate. This means that these devices will be most effective during the initial cooling operation, when the temperature of the product is close to the external ambient, and the most heat has to be removed. As the product temperature drops, the efficiency of the cooling will fall also, but so does the rate of cooling (by Newton's law).



We used these data and derived equations to develop a spreadsheet that models the time taken for 5 100W Peltier blocks, run from a 100W solar panel (8 amps, 12V) to cool 100 kg of potatoes. As can be seen, the potatoes will cool, in theory, to 0 C in a quite satisfactory 30 hours.



Obviously this is a relatively small mass of product, but increases in volume of product could be accommodated by increased numbers of panels and capacity or number of Peltier blocks. We have purchased four 100W Peltier blocks, a large insulated cooler, and associated hardware in order to run an empirical test of cooling under the conditions modeled above.

D.C. split air conditioner/CoolBot for a solar-powered cool room

We are frequently reminded of the need for a cooling solution that is not dependent on grid electricity. In a companion project in Bangladesh, we have been testing photovoltaic panels and gas generators as possible solutions. Photovoltaics will provide adequate cooling for relatively low cost in combination with the CoolBot/insulated room solution, but of course cooling is not available in the evenings and during periods of heavy cloud. An Excel spreadsheet has been developed to model the likely energy demand for a cooler, based on the size of the room and insulation. In addition to indicating the required refrigeration capacity, the program predicts the temperature rise when the cooling system is not operating. Surprisingly, a well-insulated room full of cooled product is predicted to warm quite slowly, indicating that a correctly operated room could be adequately cooled with photovoltaic electricity alone. We are continuing to explore the possible implementation of direct solar cooling offered by specially adapted 'inverter'-type split air conditioners. Although presently expensive, these units should theoretically be cheaper than standard air conditioners, since they do not need to convert incoming AC to DC. Eliminating the rectifier will potentially make the system more energy efficient than a traditional air conditioner.

There are several approaches to running the CoolBot system with solar energy. The important thing to know is the overall electricity demand of the system. A well-insulated room will need relatively little energy to maintain temperatures, so the major refrigeration demand is for cooling incoming product. The CoolRoom energy spreadsheet noted above provides an interactive model that allows the user to input the characteristics of the room and the demands of room operation (temperatures inside and outside, amount of product loaded per day etc.), and to estimate the energy demand, size of air conditioner required, and likely rates of increase in temperature when the air conditioning is turned off.

Possible solar-based systems include:

1. Panels, charger, inverter, and batteries to run the CoolBot/air conditioner system. A 12,000 BTU air conditioner (1000W) running on a 40% duty cycle, and a 6 hour solar day will require 9,600 (24 x 1000 x 0.4) watt hours to run the air conditioner, and enough panels to generate 1,600 watts, 8 200 W panels minimum. Since there are 18 hours without significant electricity generation, 7,200 watt-hours of electricity would need to be supplied from battery storage. This would require batteries with a capacity of 300 (7,200/24) ampere-hours. Given that batteries function best if they are not drawn down below 30% capacity, 400 ampere hour batteries would be minimal. These are all feasible numbers, and the total cost of the system (roughly, using US prices) would be:
Panels - $2,000
Charger - $500
Inverter - $2,000
Batteries - $700
Total - $5,200
Total including a $600 cost for the AC unit - $5300

2. Panels, charger, inverter, and batteries to run the system only during daylight hours. In this model, a regular automobile or truck battery is used as a buffer to provide the extra current required to supply the inrush current when the air conditioner starts up, but is not intended to supply refrigeration during the night. This system would require only sufficient panels to provide for the immediate needs of the air conditioner. Since this will be the period of product loading and high daytime temperatures, assume a 60% duty cycle, and perhaps a larger air conditioner to provide quicker pull-down, so you might estimate 60% duty cycle with a 1,500W air conditioner, which would require 6 200W panels. Costs for this system would be somewhat less:
Panels - $1,500
Charger - $500
Inverter - $2,000
Battery - $150
Total - $4,150
Total including a $600 cost for the AC unit - $4,750

3. Panels, charger, and battery to run the system using a DC air conditioner. The new 'split system' air conditioners are so called 'inverter' systems, in which the incoming AC is rectified to DC, then an inverter is used to generate a three phase AC whose frequency varies according to the compressor demand. This system is much more efficient, and obviously could readily be converted to DC operation by removing the initial rectifier (which should decrease the cost!). Some units that run directly off DC are now available on the market, but they are relatively expensive, with costs of about $2,000 for a 15,000 BTU/hr AC unit.
Panels - $1500
Charger - $500
Batteries - $150 - $750 (depending on whether you want to run during the night or not)
Total, including $2,000 for the AC unit - $4,150 - $4,750

These calculations don't include the cost of the coolbot unit ($200), nor the cost of a power supply to the coolbot and the lights in the room, which could be a small battery/inverter system ($200).

We plan to purchase a DC-capable AC unit and test its function with the solar panels and batteries that were used in a previous (IIP) HortCRSP project.

Reducing the cost of running generators for off-grid CoolBot coolrooms

Gas generators are inexpensive relative to the cost of solar panels, but are expensive to operate. Although they use less fuel when idling, they operate at low efficiency and continuous operation uses a lot of fuel. This is particularly true of generators sized to run an air conditioning or refrigeration system, which need to have sufficient capacity to provide the high inrush current (typically 3 to 5 times the operating current) of the compressor motor. In discussions with Ron Khosla, the inventor of the CoolBot, we have considered a variety of ways to reduce the cost of operating coolrooms using generators. The most promising appears to be the use of a system that combines a storage battery (automobile or truck) and an inverter/charger connected to the generator and the battery. The key element would be an automatic switch that would turn on the generator when the battery voltage falls below a set minimum. AC generated by the inverter would drive the CoolBot/Air conditioner, lights, and fans. This concept is very similar to the engine/battery system in a hybrid automobile. We plan to test a system of this type in Bangladesh next year. We expect that it will greatly reduce the cost of running the coolroom with a generator, and reduce the size of generator required (which will further reduce the capital and running costs).

In the companion potato storage project in Bangladesh, we plan to test this approach as a means of operating already-constructed CoolBot coolstores.

Innovative insulation

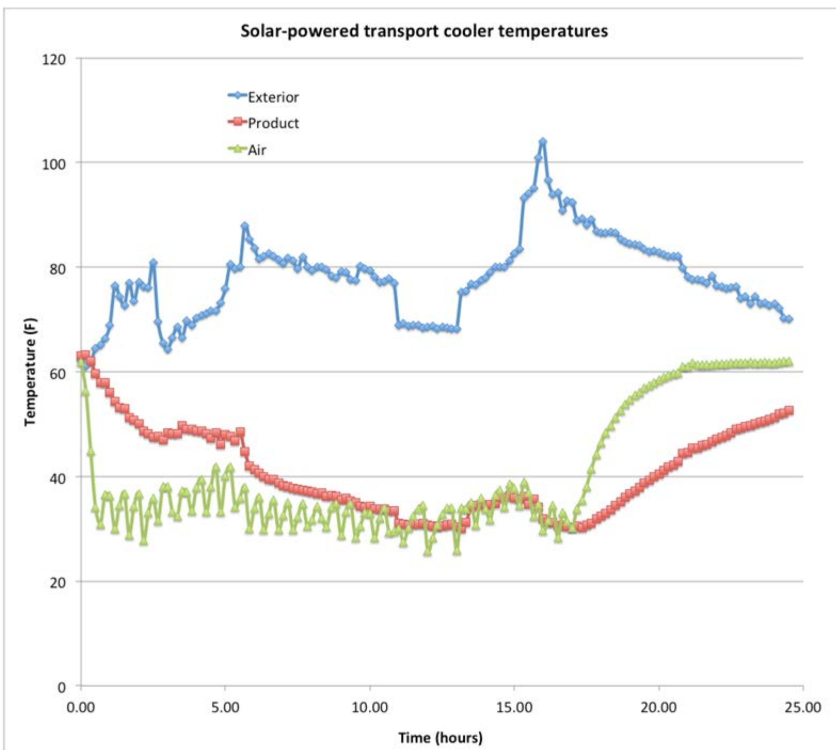
Testing of the model for small coolrooms shows clearly the importance of high quality insulation. In a companion project, we installed CoolBot/AC systems in rooms made with Polyurethane Structural Insulated Panels (SIPs), which have a high R-value and are standard materials for coolroom construction in the developing world. They are, however, very expensive, and we propose to test other strategies, particularly retro-insulation of existing structures, or inexpensive structures built with local materials. Two specific possibilities are a portable polyurethane spray system that comprises two pressurized bottles and a mixing nozzle. At US$600, these systems will spray 1" of PUF on 600 square feet, sufficient to provide moderate insulation in a 36 m^3 room. Another interesting possibility is the use of 'Aerogel' insulation, which is now being produced commercially and used to retrofit manufactured homes. Although presently expensive, its cost is expected to fall as manufacturing processes scale up and become less costly. It has very high R-values, and we have purchased a roll to test how it works in retro-insulation.

Small-scale transportation and cooling

A common problem for small-scale farmers in the developing world is the limited availability of transportation, and the almost universal

absence of refrigerated transportation. Product is often transported on foot, by bicycle, motorbike, tuk-tuk or small truck, almost always in conditions that exacerbate water loss, temperature-related deterioration, and physical damage. We looked at some opportunities in improving transport of horticultural crops for very small growers, and commissioned the construction of a simple but sturdy bicycle trailer constructed of welded conduit. The trailer was sized to fit a commercial cooler/ice chest. This device, which includes a 70W refrigeration compressor, can operate as a freezer or refrigerator, and can be run from a 100 W solar panel.

In our tests, we showed that product could be cooled in this chest using a 100 W solar panel (with a small battery and charge controller to ensure stable voltage). The graph below shows the temperatures outside and inside the chest during a one-day test with a 10 kg bag of potatoes as the ‘product’. Temperatures inside the cooler quickly fell to the set point. The thermostat in this commercial unit was relatively coarse (presumably to protect the compressor), and temperatures oscillated around the set point by +/- 5 °F. Without any system in the chest to move air and increase cooling rates, the potatoes cooled relatively slowly, reaching the set temperature after about 12 hours. Once the power source was removed, the chest warmed over a period of 3 hours; the potatoes took a good deal longer to warm, and were still below 50 °F 7 hours after the power was removed. These data suggest that a chest of this sort could be useful in local marketing of perishable products.



The transport cooler could be used in several ways. It could be used to cool the product, and then disconnected from the solar panel to allow transport of the product to market. Alternatively, the solar panel could be mounted (with simple vibration dampers) on the lid of the cooler so that cooling could continue during transport and at the market. The glass cover of typical solar panels is extremely durable, and might even serve as a ‘counter’ for display and sale of produce in the market. The unit that we have been evaluating has a control system that allows it to be used as a freezer, so another mode of operation would be to use the cooler at the farm to freeze water in plastic bottles or bags, which could then be included in separate insulated boxes for product cooling during transportation.

We are particularly interested in the application of the Peltier principle to cooling in larger insulated boxes that might fit on the back of a small pickup truck. An auxiliary alternator fitted to the engine of the truck would provide adequate current for driving a Peltier block array. The lack of moving parts and opportunity for precise temperature control is an important potential benefit of such a system. We have purchased some aerogel insulation to test the possibility that this high-technology insulation might permit easy insulation of simple storage boxes to fit on the back of a pickup truck or trailer.

Dry chain strategies

In an early IIP project, HortCRSP funded an effort to increase the cost effectiveness of solar dryers for fruits and vegetables, particularly tomatoes. In our previous report, we described the low cost and high efficiency 'stack' dryer that we developed and tested. This dryer was described to participants at the annual postharvest short course, June 2013, in Davis, and we are delighted that it has since been tested in Pakistan (right) and in Uzbekistan (below). In Uzbekistan, growers have built 20 dryers in different configurations, but all with the essential features of our dryer – a 'tunnel' with the product located at the top of the tunnel, and a chimney at one end of the tunnel to provide air at high

speeds through the tunnel. The important characteristic of this design (now known in Uzbekistan as the 'Thompson Dryer') is its flexibility – it can be made from a wide range of materials, and in a variety of sizes and configurations. One of the most intriguing aspects of the use of the dryer in Uzbekistan is in drying grapes. Growers have built stack dryers with strings under the tunnel covering to suspend the grape bunches, so that the final raisins are round, as required by their markets in Eastern Europe.

We are collaborating with Gholibjon Mahmudov, Engineering Manager of the Uzbekistan Aglinks Plus Project funded by USAID, to further develop the dryer. The aim is to greatly expand capacity and reduce cost per kg/day, principally through reducing cost of, or developing alternatives to the drying trays, which are the most expensive part of the system. Alternatives to be tested are paper, spun-bonded polyethylene (Tyvek), and cloth.

Monitoring and maintaining the dry chain

In addition to drying fruit and vegetables, we are very interested in using the HortCRSP solar dryer for grains and pulses. A major problem in the developing world is the inefficient systems available for drying and storing cereals and other staples in the humid tropics. The chronic presence of aflatoxin in these stored materials affects health and nutrition. We think that dryers based on the HortCRSP solar dryer may be well suited to drying grains and pulses – the goal is to generate high air flows at moderate temperatures so that germination is not affected. We plan to test the system in California with corn on the cob to develop information that can be used in subsequent tests in Africa and elsewhere.

Kent Bradford has advanced the concept of the 'dry chain', analogous to the cool chain, for preservation and storage of dried materials; we embrace this concept and are interested in contributing innovative technologies to it. We suggested replacing the digital humidity meters that Kent was using to monitor storage humidity with inexpensive RH 'strips' based on $CoCl_2$. These strips change color from blue to pink as the humidity rises, and inexpensive multi-dot strips are available that allow estimation of RH within 10%. This technology is very inexpensive; a single strip may cost only a few cents, and is accurate enough to have been used to monitor the storage environment for US military supplies. While these strips are fine for use with stored seeds, toxicity concerns over the use of $CoCl_2$ means that they are not suited to storage of dried foods. We have ordered and will test strips that are cobalt-free. These tests are conducted by using saturated salt solutions in enclosed containers (which generate a steady RH). Different salts have different equilibrium humidities. We will compare the humidity in the chamber with the graduated test strip readings, using a chilled mirror electronic psychrometer as a reference to determine the exact RH.

Traditionally, dried food materials have been stored in well-ventilated spaces. Unfortunately, such storage is often associated with rodent infestation, insect predation and fungal attack. Sealed storage systems like the 'Purdue bag' are of considerable interest, but unless the stored material is sufficiently dry, there is a risk of fungal and even insect contamination within the sealed container. Kent Bradford suggests the use of Zeolite drying beads as a tool to reduce water activity so as to prevent these problems in sealed storage containers. This seems a valid approach, but may prove too expensive for smallholder farmers. We are testing alternative desiccants, including maize dried to low water content in the solar dryer, and Tyvek sachets containing $CaCl_2$. Calcium chloride is a hygroscopic salt that establishes an equilibrium RH of 31% at room temperature. It is non-toxic, cheap, and reusable, and could be an excellent alternative to the drying beads for storage of dried food materials and even seeds. At 31% RH, the storage life of seeds is greatly extended, and the use of this equilibrium technique obviates the need for the calculations of moisture content that are suggested in the use of zeolite drying beads.

Capacity Building

The project funded a UC Davis student. He assisted with building and testing the project's technologies, and was trained in data collection.

Project Name: UC Davis D-Lab & Horticulture CRSP Innovation Centers: Providing support & capacity building to bring appropriate technologies to market

Project Description: Among the most promising disruptive technologies for application to horticulture are those that address the uses of energy in the production, marketing, and processing of horticultural crops. This project proposes to test a range of sustainable energy solutions, and to deploy the most promising at Horticulture CRSP's Regional Centers of Innovation.

As part of a larger capacity-building effort, this project will integrate activities at the Horticulture CRSP Regional Centers of Innovation in Thailand and Kenya into ongoing work at the UC Davis D-Lab. UC Davis D-Lab faculty mentors and graduate student teams will collaborate with the Regional Centers of Innovation partners through a structured approach for performing feasibility studies, technical and market assessments, and design development on innovative horticulture-focused energy technologies. Through this process, the centers will gain new methods for evaluating and developing horticulture innovations, better enabling them to attract investment and initiate dissemination of these technologies.

Collaborators:

- Dr. Arie Sanders, Director of the Department of Environmental and Development Studies, Zamorano University, Honduras
- Julio Lopez Montes, Director of Innovation Center, Zamorano University, Honduras
- Dr. Siwalak Pathaveerat, Professor, Postharvest Technology, Biological and Agricultural Engineering, Kasetsart University, Thailand
- Dr. Poonpipope Kasemsaap, Vice President for International Relations Kasetsart University, Thailand

Key Accomplishments:

- D-Lab I: Energy and Development: An Overview, was offered at UC Davis.
- D-Lab II: Energy and Development: Designing for the Market, was offered at UC Davis.
- Zamorano D-Lab was implemented in Honduras and an evaluation was conducted.
- Kasetsart D-Lab was implemented in Thailand.

Technical Narrative:

UC DAVIS D-LABS
In October-December 2012 the Davis D-Lab began preparing for Winter and Spring D-Labs.

In winter quarter 2013 D-Lab I: Energy and Development: An Overview, was offered. The class gave an overview of energy issues in developing economies that emphasized critical thinking. Curriculum included four hands-on energy labs, a business development clinic, case studies, and guest speakers. Multi-disciplinary teams worked with local partners to perform feasibility studies for proposed energy solutions. 23 graduate students from various background completed the course.

D-Lab I projects of Winter 2013
Energy Hub in Uganda; Partner: Access2Innovation & World Wildlife Fund, Uganda
In Uganda, less than 10% of the country's household's are connected to the national grid for electricity and instead mostly use kerosene, which has human health, environment, and high financial costs (CIRCODU). Access to high-quality, affordable light could improve standards of living by providing households with substantial savings, better nighttime light quality, reduced health risks, and environmental consequences.

Electricity Feasibility Study in Ghana; Partner: Dr. Tometi Gbedema and the Otwetiri Project
The goal of this project is to develop a feasible plan for electricity in the community of Otwetiri in order to appropriately address the community's energy needs, amounting to 7.78 kWh/day for increased educational opportunity and cell phone charging with the potential to scale up in the future. The scope of the project is dependent on the services desired and the willingness of the local community to pay for solar expenses. Current energy expenditures are $1.26 for cellphone charging per person/day, not inclusive of kerosene lighting, and $1.41 with kerosene lighting.

Solar Irrigation in Uganda; Partner: Michael Reid & Gloria Androa
The project outlined in this paper is to provide a pumping solution for the village of Ewavio, Uganda. Ewavio has a need to develop technologies that will increase the amount of water available to villagers (for farming and household use) and decrease the amount of time spent pumping the water during the dry season. This project designed a solar pump to replace the current manual pump and analyzed the economic and social feasibility of such an installation.

Seed Saving Feasibility Study in Thailand; Partner: Educational Concerns For Hunger Organization (ECHO)
This report examines the use of zeolite beads for seed saving in Chiang Mai province, Northern Thailand. It assesses the viability of using zeolite at a seed bank owned by the Educational Concerns For Hunger Organization (ECHO) that is preserving indigenous crop varieties in Mae Ai. This report also assesses whether zeolite is a viable technology for hill tribes in the region. The methodology of this study attempts to analyze zeolite technology use through the four lenses of sustainable development as defined by D-Lab: technical, financial, social, and environmental.

Solar Fruit Drying in Ecuador; Partner: Kiwa
The goal of this project is to find a viable solar drying system to produce dehydrated fruit (mango, banana, naranjilla and tomate dearbol) in the subtropical climate of Ecuador. We seek to expand production capacity at KIWA, lower energy input costs, and increase product life and quality. The establishment of improved technologies will be leveraged by simultaneously advancing relationships with small-scale producers to create a more secure, sustainable future for the company and growers.

In April 2013, D-Lab II: Energy and Development: Designing for the Market was offered. The class offered a studio-style design course that focused on low-cost energy solutions for the developing world. Student teams work with local partners and mentors, to design, prototype, and test scalable solutions for real world energy problems for their client communities. Curriculum included lab modules, business development skills, case studies, independent research, and guest speakers. 19 graduate students from various disciplines completed the course.

D-Lab II projects of Spring 2013
Solar Fruit Drying in Ecuador; Partner: Inaproces-KIWA

Kiwa approached the UC Davis D-Lab expressing its interest in expanding the Kiwa brand and exploring solar technologies for dehydrated fruit chip production. Kiwa hopes to reduce the costly energy it consumes in its current frying process and increase the environmentally friendly image of its brand. In the spring of 2013, our D-lab team developed a rooftop air preheating unit that utilizes solar energy to increase the temperature of the air entering a gas burning fruit dryer

Rubber Tapping Knife in Thailand; Partner: Kasetsart University, Thailand
The D-Lab's objective was to design and develop an improved rubber tapping knife that can deliver a thinner cut into a rubber tree bark that will maximize the rubber tree life cycles and in turn, reduce farmer payback periods and generate increased revenues. The potential impact includes a 3x increased life cycle, 1/3 farmer payback cycle, $1B national revenue increase.

Mobile Irrigation System in Uganda; Partner: Agriworks Uganda Ltd
The mission of Agriworks is to offer client services to small- and medium-scale rural farmers so that they can better implement extension recommendations and good agricultural practices. One of the first projects initiated by Agriworks was the development of a mobile irrigation service technology called AMIS (Agricultural Mobile Irrigation System). For the scope of this project D-Lab has been asked to construct a frame for the AMIS components that will reduce the amount of time currently spent on setup and breakdown time.

Off-Grid Zeolite Bead Regeneration in Thailand; Partner: UC Davis United States Agency for International Development’s Horticulture Collaborative Research Support Program (USAID HortCRSP) office, Educational Concerns For Hunger Organization (ECHO) Asia, and Kasetsart University in Thailand
This study designed and prototyped offgrid technologies for recharging zeolite beads, a desiccant for horticultural seed saving, by two primary stakeholders in the Chiang Mai region of Northern Thailand: ECHO Asia’s seed bank in Mae Ai, and smallholder farmers in the Chiang Mai and Chiang Rai regions, the Palaung and Lahu hill tribes.

D-LABS IN THAILAND AND HONDURAS
Honduras: UC Davis D-Lab began to work with Zamorano University in Fall 2012. The Zamorano Pan-American Agricultural School is a private undergraduate agricultural university serving approximately 1,200 students from throughout the Americas. The Zamorano campus covers over 12,000 acres, and includes agricultural fields, a dairy, a mill, food processing facilities, and many other examples of agricultural industry. In recent years Zamorano has taken steps to continue its work as a leader of innovations in agriculture, notably establishing the stove testing center and the opening the Horticulture CRSP Regional Center of Innovation at Zamorano in 2012.

In the fall of 2012, Principal Investigator, Kurt Kornbluth and a team of students traveled to Zamorano University, Honduras to establish a foundation for collaborative work between D-Lab and Zamorano University. The goals of the trip were to tour the Zamorano facilities, conduct a D-Lab exercise with Zamorano students, participate in a Zamorano-taught lab, and meet with the Zamorano department heads and staff to draft a plan for future collaborative work on a Zamorano D-Lab Class.

During this trip (and with Horticulture CRSPs help!) UC Davis D-Lab was able to identify management in the Zamorano Department of Environment and Development Studies, Arie Sanders and Alfredo Reyes to begin collaboration discussions. The Director of the Forestry Department, Tim Longwell, and Jorge Espinosa, was also brought in to discuss logistics of a Zamorano based D-Lab.

In the Spring 2013, Jorge Espinosa, the Zamorano D-Lab instructor, came to UC Davis to learn more about the design process and the UC Davis D-Lab class. (See trip report for more information). In July 2013 the inaugural Zamorano D-Lab began. The class is segmented into three work modules, each lasting 3 weeks with 15 students each. The students are exclusively in the Environmental Engineering Department and are undergraduates in their final (4th) year.

A second trip to Zamorano University by UC Davis D-Lab in July 2013 to do an evaluation of the inaugural D-Lab. Preliminary results seem to point to a very successful class. The Zamorano D-Lab has been very successful in implementing a D-Lab class that encapsulates the essence of design and development, as well as being a very positive experience for students. Management in Zamorano and in Davis are dedicated to making this an initiative that is beneficial to fledging designers as well as local agriculture communities in Latin America; and looks forward to opportunities for growth and collaboration in years to come.

Thailand: UC Davis began to work with Kasetsart University in the Winter of 2012. Kasetsart University is a major public research university in Thailand with its flagship campus located in Kamphaeng Saen and Bang Khen, Bangkok.

In February 2012, UC Davis D-Lab traveled to Thailand to establish a foundation for collaborative work between UC Davis D-Lab and partners at Kasetsart University (KU) and Educational Concerns for Hunger Organization (ECHO). The goals of the trip included meeting KU and ECHO staff, familiarize D-Lab with on the ground situations and challenges, and to draft a plan for a future Kasetsart D-Lab class.

During this trip UC Davis D-Lab was able to identify management in at the Thailand Innovaion Center, Executive Director Poonpipope Kasemsap and Kasetsart Professors Siwalak, Kietsuda, and Nonglak. To work collaboratively on a Kasetsart D-Lab.

Specifically, KU is planning to offer D-Lab curriculum so that innovation and design capacity is institutionalized at KU and collaborative project efforts can be incentivized and strengthened. For the first time, KU students will receive innovation and design education and academic credit for their D-Lab coursework. This will help address the collaboration challenges associated with different academic calendars, educational objectives, and communication by creating common educational objectives, incentivizing KU students' participation, and allow for integrated course deliverables on joint projects.

The course will be co-taught by relevant and already designated faculty across biological and agricultural engineering, horticulture, and energy and environmental engineering departments (Siwalak, Kietsuda, and Nonglak). The class is officially in the Kasetsart University course catalogue and will be offered starting in November 2013. UC Davis D-Lab is supporting in curriculum development. In order to support this effort and assess progress, another trip to Thailand will be made in November 2013.

Capacity Building:
Graduate Student Researchers and Assistants
Erin McGuire, MS International Agriculture Development
Nadya Alexander, MS International Agriculture Development
Tom Stein, MS International Agriculture Development and MS Soils and Biochemistry
Randall Paul-Cass, MS International Agriculture Development
Natalie Svoboda, BS College of Engineering

Professional Training:
Design Process and D-Lab Training – Fellowship at U.C. Davis
Jorge Espinosa, D-Lab Instructor, Zamorano University

Design Process and D-Lab Training, Workshop at Kasetsart University
Dr. Siwalak Pathaveerat, Professor, Postharvest Technology, Biological and Agricultural Engineering, Kasetsart University, Thailand. Workshop at Kasetsart University.
Nonglak Samantart, Assistant Director, Professor, Energy and Environmental Engineering Center (EC3)), Kasetsart University, Thailand
Kietsuda, Professor, Horticulture, Kasetsart University, Thailand

University Capacity and Partnership Building:
Kasetsart D-Lab, Thailand
Zamorano D-Lab, Honduras
UC Davis D-Lab I and II, USA

Presentations and Publications:

1. Draft of Economics of Zeolite Beads for Seed Saving (by Karina Lundhal, Julia Shuck and Sarah Sahlaney)
2. Zamorano D-Lab Evaluation
3. Student Reports on D-Lab technologies:
    - Energy Hub in Uganda
    - Electricity Feasibility Study in Ghana
    - Solar Irrigation in Uganda
    - Seed Saving Feasibility Study in Thailand
    - Solar Fruit Drying in Ecuador
    - Rubber Tapping Knife in Thailand
    - Mobile Irrigation System in Uganda
    - Off-Grid Zeolite Bead Regeneration in Thailand

Appendix 2
List of Awards given to U.S. Universities

List of awards given to U.S. universities

U.S. university	Project name	Project dates	FY13 funding	Total funding
Michigan State University	Demonstrating nets and floating row covers	Oct. 2011 to July 2014	$160,722	$500,000
North Carolina A&T State University	Empowering women vegetable growers with drip irrigation	Oct. 2012 to July 2014	$15,000	$15,000
Purdue University	Strengthening value chain for African indigenous vegetables	Oct. 2012 to July 2014	$427,871	$979,856
Rutgers University	Improving postharvest practices with local market support	Oct. 2012 to July 2014	$86,634	$250,000
The Ohio State University	Delivering food safety education through social networks	Oct. 2012 to July 2014	$58,718	$149,999
Tuskegee University	Strengthening the value chain for orange- and purple-fleshed sweet potatoes	Oct. 2012 to July 2014	$236,728	$250,000
University of California, Davis	Implementing drying beads for seeds	Oct. 2012 to July 2014	$306,907	$999,936
University of California, Davis	Opening a regional postharvest training center	Oct. 2011 to July 2014	$137,538	$491,273
University of Wisconsin-Madison	Producing local, disease-resistant vegetable seed	May 2012 to July 2014	$105,768	$493,523
University of California, Davis	Creating a market niche for 'food-safe' vegetables	Oct. 2011 to July 2014	$292,350	$655,070
University of California, Davis	Developing a participatory extension model to enhance smallholder production and marketing	Oct. 2011 to July 2014	$81,567	$437,232
University of California, Davis	Developing energy solutions for horticultural production	Oct. 2012 to July 2014	$50,000	$193,431

Tuskegee University and North Carolina A&T State University are Historically Black Colleges and Universities.

Appendix 3
Success Stories

HORTICULTURE INNOVATION LAB PHOTO / AMANDA CRUMP, UC DAVIS

A UC Davis researcher works with new postharvest trainers from Kenya, Tanzania and Ghana to prepare amaranth leaves for a solar dryer demonstration. This processing demonstration is part of a Horticulture Innovation Lab project that trained more than 16,000 farmers in improved postharvest practices over two years.

REDUCING FOOD LOSSES THROUGH POSTHARVEST TRAINING

Once harvested, 30-80 percent of fruits and vegetables in Sub-Saharan Africa are lost to poor handling. Food quality, safety and nutritional value are also affected by poor postharvest practices.

In an effort to improve postharvest handling of horticultural crops, Feed the Future partners opened a model postharvest center in Tanzania and deployed newly trained experts from seven countries to train farmers.

This project's model calls for five components to make a self-sustaining Postharvest Training and Service Center: training of trainers, on-site training and demonstrations, adaptive postharvest research (including cost-benefit analyses), a public retail shop for postharvest equipment, and providing fee-based postharvest services such as cooling.

In October 2012, 36 professionals from Tanzania, Rwanda, Kenya, Uganda, Ethiopia, Ghana, and Benin completed a year-long training in postharvest practices, led by an international team under the Feed the Future Innovation Lab for Collaborative Research on Horticulture.

Through online learning and mentoring, the trainer candidates each completed a series of 10 assignments ranging from assessing commodity systems to developing training programs. The trainings were led by Lisa Kitinoja of the World Food Logistics Organization, with Diane Barrett of the University of California, Davis, and additional training support from the University of Georgia, AVRDC-The World Vegetable Center, Amity University, UC Davis, and the Postharvest Education Foundation.

These 36 new postharvest trainers became the first graduates of the new Horticulture Innovation Lab Postharvest Training and Services Center, located at AVRDC-The World Vegetable Center in Arusha, Tanzania. The trainers learned about a variety of postharvest technologies, including the use of shade, harvesting tools, packaging, containers, grading, washing, cooling technologies, drying, and processing. They learned how to use various tools, including sizing rings, color charts, chlorine test strips, and refractometers, to measure postharvest quality.

Then new trainers officially opened the center by leading more than 100 local farmers through a day of postharvest instruction and demonstrations. Upon graduating, each of the trainers received a postharvest toolkit to help them get started with their next task—training farmers in their own countries and ultimately opening up their own postharvest training and service centers.

In 12 months following their graduation, the 36 trainers have directly trained 7,474 farmers in postharvest practices and technologies across seven countries, with a potential multiplier effect of an additional 8,900 practitioners.

Designs for more than 80 additional Postharvest Training and Services Centers—including suitable sites, partners and costs—have been developed by trainers who took the year-long course.

Experts affiliated with the Horticulture Innovation Lab also continued to offer training through the center in Arusha for small-scale growers, marketers and processors. Over a two-year period that included the train-the-trainers, more than 16,000 farmers were trained in improved postharvest practices through this project.

"Many of our new 'postharvest specialists' are already working together on postharvest research projects or writing new proposals for training programs," Kitinoja said. "Others have been hired for consulting assignments in the region or awarded fellowships that will allow them to continue their postharvest studies and/or extension work in their own countries."

Mosquito Net Company Partners with Research Institutions to Tackle Crop Pests
B. Dawson

Bed nets are nothing new in international development, but a leading company in mosquito netting has turned its attention – and its nets – toward improving agriculture.

Under Feed the Future, a collaborative research project has brought together A to Z Textile Mills in Tanzania with agricultural researchers to test the utility of its nets for growing fruits and vegetables.

The project is funded through the Feed the Future Innovation Lab for Collaborative Research on Horticulture, with researchers from Michigan State University, CIRAD of France, Egerton University in Kenya, Abomey-Calavi University in Benin, the Kenya Agricultural Research Institute and the National Agricultural Research Institute in Benin (INRAB).

Through field trials, this team is fine-tuning how smallholder farmers can use the nets to mitigate damage from insect pests and improve micro-climates in vegetable plots. Similar to its long-lasting insecticidal bed nets, A to Z's "AgroNets" were developed both with and without chemical treatments to evaluate which kinds of nets best protect different crops. The nets can also be re-used for multiple growing seasons.

"This technology is, for the first time, adapted to smallholder farmers and available in Africa because of the mosquito net industry," says Thibaud Martin, a CIRAD scientist based in Kenya. "This technology is truly an effective alternative to chemical use."

With the intention of eventually selling nets to farmers commercially, A to Z donated nets and supplied their transport for the purposes of the research project, delivering 1.5 tons of netting to Benin, Kenya and CIRAD partners in just the first six months.

"Partnership with A to Z was critical to the success of this project," says Mathieu Ngouajio, professor at Michigan State University and a leader of the Horticulture Innovation Lab project. "They have made all the fine-tuning that we needed on the nets and supplied our team with the material for field studies. Without that type of support, it would have been impossible to achieve our project goals."

After two years of research, results in Kenya show the nets can indeed reduce pests and increase yields in tomato, cabbage, kale, onion, French bean, melon and carrot crops. Farmers have also tried the nets with other crops such as sweet peppers, amaranth, spider plant and strawberries.

"Use of AgroNets on cabbages, tomatoes (both field and nursery), French beans and melons is not only efficacious against pests, but also offers great business potential for A to Z," says Hubert Coffi, agronomist with A to Z's research unit, the Africa Technical Research Center.

In Benin, adoption of the nets by farmers has been particularly high. More than 75 percent of farmers who participated in the trials adopted the nets for use with nursery production.

Since the project started, the team has received additional funding from CIRAD, INRAB, Ecohort, Katarina University, SupAgro Foundation and the French embassies in Benin and Kenya.

“Moving toward agriculture is for us a key strategic pillar for the coming years because it will help us to expand and diversify our operations and revenue stream while creating more jobs,” says Dr. Johnson Odera, director of the Africa Technical Research Center. “We still believe in the future of agriculture in Africa, and we want to be part of this success story.”

The Horticulture Innovation Lab, funded by USAID under Feed the Future and led by the University of California, Davis, builds international partnerships for fruit and vegetable research to improve livelihoods in developing countries.

UC Davis Provides Innovative Model for Students in International Agricultural Research

Working in collaboration with 18 universities, the University of California, Davis leads the Feed the Future Innovation Lab for Collaborative Research on Horticulture, which builds international partnerships for fruit and vegetable research to improve livelihoods around the world.

Though the Horticulture Innovation Lab comprises a wide variety of projects directed by leading scientists, a small but important part of its portfolio is the Trellis Fund, an innovative model that pairs U.S. graduate students with organizations engaged with local farmers in developing countries. With support from the Trellis Fund, students work as partners and consultants for these organizations to help address some of smallholder farmers' most pressing technical needs. For many students, a Trellis Fund project is their first opportunity to apply their agricultural research backgrounds to professional partnerships in international development.

"We've found that Trellis is a good opportunity for students to dip their toes into international development work," says Amanda Crump, associate director of the Horticulture Innovation Lab. "An important part of graduate school is conducting research and learning how to manage research, and Trellis is giving them out-of-classroom experience in an international setting."

The Trellis Fund not only gives graduate students valuable field opportunities in food security and development, but it is also managed by students who work for the Horticulture Innovation Lab and was originally proposed by a UC Davis student.

"I think we feel closer to the program because it is managed by our peers and for our peers," says Elana Peach-Fine, a UC Davis graduate student who most recently led Trellis management. "We put a lot of heart and soul into this program because we're responsible for it, and we believe in it."

Trellis Fund projects address topics ranging from pollination-friendly farming practices to postharvest training, with horticultural crops including everything from beets to mangos. One agricultural researcher, Rachel Suits, studied entomology (insect science) at North Carolina State University and traveled to Nepal to work on integrated pest management in vegetables. During her project, she collaborated with Nepal's Ecological Services Center to reduce pesticide use in vegetables.

"One thing that was really exciting about this program was the opportunity to be fully immersed in another culture and do something that was work-related in a different country," Suits says.

Building capacity is a central tenet of Trellis Fund projects, both for the organizations and for the students. This summer, Trellis kicked off 13 new projects on fruits and vegetables around the world and will send graduate students to Uganda, Kenya, Senegal, Ghana, Tanzania, Guatemala, Nepal and Bangladesh to work with a range of development organizations, farmer groups, national agricultural research organizations and local universities. This is the third round of such projects; over its lifetime, the Trellis Fund has supported 37 projects in 14 different countries.

"I hope the Trellis students have a very real experience working in international development," Peach-Fine says. "I hope they carry the sense with them that their work as agricultural researchers has the potential to be important to a global society."

Appendix 4

Annual summary for USAID

FFY 13 FTFMS Narrative template for BFS Mechanisms
Feed the Future Innovation Lab for Collaborative Research on Horticulture (Horticulture Innovation Lab)

All text below should be in bullet form. One page maximum.

COR/AOR/Activity Manager Name:	John Bowman
Instrument Type: *(LWA, CA, PIO, Contract)*	LWA
Prime Partner:	University of California, Davis
Contract/Grant Agreement Number:	EPP-A-00-09-00004

Purpose of Activity *(**ONE SENTENCE**. Include high-level targets, goals, timeframes.)*

- In its fourth year, the Horticulture Innovation Lab continues to advance horticultural science in developing countries by increasing capacity and information access while solving problems along horticultural value chains, with emphases on gender empowerment, technological innovation, income generation and nutrient-rich crops.

Description of Actual FY2013 Activities and Results *(Discuss significant FY13 results and key FY13 activities. Describe the main beneficiaries. Why are the results important?)*

- The Horticulture Innovation Lab funded 17 active research projects in 20 countries during FY13, across a variety of fruit and vegetable crops and at various stages in the value chain.
- Our projects trained 13,577 farmers. Nearly 5,000 farmers adapted new technologies. Sixty percent of trainees were women.
- In FY13, the Horticulture Innovation Lab successfully launched its third Regional Centers, in Kenya, and saw the pre-existing two Regional Centers ramp up activities in training and coordinating meetings.
- The Horticulture Innovation Lab secured two associate awards; one to conduct an assessment of horticulture constraints in Central America and another to collaborate with the International Potato Center (CIP) in Bangladesh building and testing low-cost smallscale cooling that functions both on and off the grid.

Successes During FY13 *(How will successes lead to desired outcomes?)*

- A project highlight: In Benin, 75% of farmers participating in the project adopted pest-exclusion nets for nursery production. Adoption of nets has been shown to reduce pesticide applications.
- A project highlight: In Zambia, a focus on postharvest and the cold chain has improved production for 231 farmers who have produced 1,158 tons of produce for income of $2,034,047.
- A project highlight: The Horticulture Innovation Lab completed training 36 postharvest trainers and opened a postharvest training and services center. The trainers have in turn trained more than 16,000 smallholder farmers (this includes FY12 data).
- A project highlight: Women's cooperatives in Guatemala and El Salvador are now producing and selling improved tomato and pepper seedlings. By adding grafting to their skills and business plans, the women have now doubled their income per seedling.

Challenges During FY13 *(How is the implementing mechanism adapting to meet the challenges?)*

- Developing institutional contracts with two of the three centers of innovation was a challenge that we faced and overcame.

Description of Expected FY2014 Activities *(Describe FY14 activities from the activity work plan , FY14 indicator targets, and relate to project goals.)*

- All Horticulture Innovation Lab research projects will be completed in FY14. We will conduct a series of impact assessments and disseminate our project success stories. We anticipate having 3 to 5 technologies that are ready to scale-up. We expect to train an additional 6,000 farmers and have 4,400 farmers adopt Horticulture Innovation Lab technologies.

Relationship of Expected FY2014 Activities to the Office's Strategic Objectives *(**BFS WILL COMPLETE**. Explain how FY14 activities will relate to the intermediate results of your office, and the FTF Focus Countries in which the activity works.)*

REVIEWED BY: (name of AOR/COR/AM)	
DATE:	

Appendix 5
Latin American Assessment

USAID
FROM THE AMERICAN PEOPLE

ADVANCING HORTICULTURE

ASSESSMENT OF CONSTRAINTS TO HORTICULTURAL SECTOR GROWTH IN CENTRAL AMERICA

DECEMBER 20, 2013
This publication was produced for review by the United States Agency for International Development. It was prepared by the Feed the Future Innovation Lab for Collaborative Research on Horticulture at the University of California, Davis.

Authors: Alonso González M., Tito Livio Zúniga, L. George Wilson
Editors: Elizabeth Mitcham, Amanda Crump, Michael Reid, Britta Hansen, Brenda Dawson, Kelsey Barale

ADVANCING HORTICULTURE:

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With additional editing by
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Cover image: Farmers' fields in Almolonga, Guatemala. Photo credit: Kelsey Barale

Feed the Future Innovation Lab for Collaborative Research on Horticulture*
University of California, Davis

*also called the Horticulture Collaborative Research Support Program

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to USAID and USDA missions and staff who supported this study and provided valuable contacts and resources to conduct it, and to the Horticulture Innovation Lab support personnel at the University of California, Davis, for enabling us to concentrate on the assessment by taking care of the logistics for traveling within the visited countries, as well as preparing the workshops (consultation and dissemination). This study would not have been possible without the immense help of all people who shared their thoughts, documents and valuable time to respond to our queries, either through face to face interviews, participation in workshops and/or by responding to the online survey.

We hope that this document will provide useful guidance to the development of the horticulture sector in Central America. By doing so, it is hoped that this assessment and its recommendations will fulfill the expectations of the Feed the Future initiative—being instrumental in solving poverty, malnutrition and livelihood issues affecting the rural communities in the region.

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ACRONYMS

BID	Banco Interamericano de Desarrollo
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CGIAR	Consultative Group on International Agricultural Research
CRSP	a Collaborative Research Support Program (also known as a Feed the Future Innovation Lab for Collaborative Research)
CURLA	Centro Universitario Regional del Litoral Atlántico
DICTA	Dirección de Ciencia y Tecnología
FAUSAC	Facultad de Agricultura de la Universidad de San Carlos
FDA	U.S. Food and Drug Administration
FHIA	Fundación Hondureña de Investigación Agrícola
FHI 360	organization created in merger between Family Health International and Academy of Education Development
FSMA	Food Safety Modernization Act
GDP	gross domestic product
HLB	Huanglongbing
ICTA	Instituto de Ciencia y Tecnología Agrícola
IICA	Instituto Interamericano de Cooperación para la Agricultura
IPCC	Intergovernmental Panel on Climate Change
IPM	integrated pest management
LAC	Latin America and the Caribbean region
MRL	maximum reside limit
NARS	national agricultural research systems
NGO	non-governmental organization
OIRSA	Organismo Internacional Regional de Sanidad Agropecuaria
UC	University of California
UNA	Universidad Nacional de Agricultura
UNAH	National Autonomous University of Honduras
USAC	Universidad San de Carlos
USAID	U.S. Agency for International Development

UVG	Universidad del Valle de Guatemala
WEAI	Women's Empowerment in Agriculture Index

EXECUTIVE SUMMARY

ADVANCING HORTICULTURE

Horticultural crops, particularly vegetables and fruits, are key to increasing food security in the Feed the Future focus countries of the Central American region. Rural farm and business incomes can be increased by assisting small-scale producers to participate more fully in horticultural value chains, focusing on increased production, improved postharvest handling, value-addition through processing, and facilitated marketing. With funding provided by an associate award from the USAID Bureau for Latin America and the Caribbean, the Feed the Future Innovation Lab for Collaborative Research on Horticulture (also known as the Horticulture Innovation Lab or Horticulture CRSP) conducted an assessment of major constraints to continued growth and increased involvement of smallholder growers in the horticulture sector in Central America, based on looking at two of the region's countries (Honduras and Guatemala). This report identifies constraints to further sector growth in Honduras and Guatemala and recommends research, training, and policy initiatives to address those constraints that have potential relevance to other Central American countries' horticultural sector growth.

The evaluation team was comprised of Dr. Alonso González M. of Colombia, Dr. Tito Livio Zúniga of Honduras, and Dr. L. George Wilson of North Carolina State University, who also served as liaison with the Horticulture Innovation Lab management team. Alonso González has more than 22 years of experience in horticultural research for development, as well as experience in assessments and value chain approaches, most recently with the International Center for Tropical Agriculture (CIAT). Tito Livio Zúniga holds a Ph.D. from Cornell University in Agriculture and Rural Development and has 13 years of experience in the field, most recently for the Honduras Ministry of Agriculture as national manager of the horticulture value chain. L. George Wilson has been a Professor of Horticulture at North Carolina State University since 1975. Prior to 1975, he worked as a researcher for Chiquita International in La Lima, Honduras.

Focused on Honduras and Guatemala, the evaluation included consultation workshops in Comayagua, Honduras and Antigua City, Guatemala, a series of in-person interviews with representatives from all sectors of the horticultural value chain (60 in Honduras and 73 in Guatemala), a web-based survey, and dissemination workshops at La Lima, Honduras and Antigua City, Guatemala. More than 190 people participated in person for interviews and workshops, including representatives of grower associations, trading organizations, financial institutions, input providers, universities, non-governmental organizations, and government. Constraints to the horticulture sector were discussed among the participants at each workshop and opinions were captured for this report. Our findings and recommendations were based on the totality of information collected from small group interviews, workshops, and survey respondents, representing broad coverage of the horticulture industry and associated sectors. Therefore, the prioritization of constraints and recommendations may require adjustment to account for specific local conditions within each country.

The evaluation was designed to serve as a springboard for new initiatives to address the constraints that limit the success of small-scale farmers in the horticultural industries in the Central American region. The workshops, interviews, and survey provided strong feedback on constraints to improving smallholder profitability in the horticulture value chains and on potential research, training, and policy initiatives to address those constraints.

CONSTRAINTS TO GROWTH OF THE HORTICULTURE SECTOR AND INCREASED PARTICIPATION OF SMALLHOLDER FARMERS:

LACK OF ACCESS TO ADEQUATE AND AFFORDABLE CREDIT AND CROP INSURANCE

Without access to credit, smallholder farmers—especially women and indigenous peoples—are limited in their ability to invest in inputs and infrastructure to enhance their crops. Needed inputs include quality seeds and plants, fertilizers, crop production and protection supplies, postharvest equipment and supplies, and infrastructure. Farmers do not invest in inputs for horticultural production due to insecure markets and a lack of funds to invest.

LACK OF AN ADEQUATE EXTENSION SYSTEM

There are few formal systems for communication of research needs and research findings between smallholder growers and horticultural researchers and research institutions. In fact, there is little transfer of well-established best practices to farmers.

POOR ACCESS TO HIGH-VALUE MARKETS

Most smallholder farmers, especially women and indigenous peoples, sell their produce through low-value venues, including direct sales in local markets or selling to intermediaries. Markets are difficult to reach due to distance and poor roads. Prices are volatile and smallholder farmers have little power in dealing with essential intermediaries.

WEATHER, CLIMATE VOLATILITY AND CLIMATE CHANGE

The Central American region is particularly vulnerable to weather-related events (drought, flooding, freezing, strong winds), which impact horticultural production, alter flowering/fruiting cycles and planting dates, increase vulnerability to pests and diseases and often result in severe economic losses. Temperatures in the region are expected to increase. Soil water holding capacity and fertility are reduced with poor soil conditions, and thus crop yield potential under climate change conditions. Irrigation, water harvesting and water storage strategies will become even more important.

PESTS, DISEASES, AND WEEDS

Horticultural crops in the Central American region are subject to attack by an array of pests and diseases, frequently resulting in major losses or intensive use of pesticides. Implementation of the Food Safety Modernization Act in the U.S. may push some smallholder farmers out of the export market due to its strict requirements.

LACK OF RESEARCH ADDRESSING REGIONAL, NATIONAL, AND LOCAL ISSUES OF THE HORTICULTURE SECTOR

Although a number of quality institutions conduct research and teaching on agricultural production and pest management for the region, targeted research on horticultural crops is limited by lack of financial and human resources. Capacity for research on postharvest and marketing issues is especially low. There is a lack of training at the Master's and Ph.D. levels.

POSTHARVEST LOSSES AND FOOD SAFETY

More than 30 percent of the yield of many horticultural crops is lost after harvest as the result of mishandling or the lack of adequate postharvest infrastructure. Moreover, access to international markets requires rigorous attention to food safety, during production and postharvest, particularly under the new U.S. Food Safety Modernization Act.

KEY RECOMMENDATIONS FOR RESEARCH, TRAINING, AND POLICY INITIATIVES:

REGIONAL APPROACHES

1. Promote initiatives to **adapt horticulture to climate volatility** through better adapted varieties, protected culture, increased access to irrigation systems, and better weather forecasting.
2. Establish **regional research programs to address cross-cutting constraints** affecting the region, particularly new pests and diseases and sustainable production systems.
3. Promote regional and national **training and education programs on appropriate technologies to reduce postharvest losses** and comply with the Food Safety Modernization Act (FSMA).
4. Promote regional initiatives to conserve, characterize, and facilitate access to diverse and **improved germplasm of horticultural species**.

NATIONAL APPROACHES

1. Reduce the economic risks to horticulture farmers through availability of **effective crop insurance** programs.
2. Design and test an **interlinked microcredit-index insurance** product.
3. **Improve national extension systems** to ensure research information, best practices, knowledge and technologies are delivered to smallholder farmers.
4. Develop trusts or other microfinance means for **financing smallholder farmers**, particularly women.
5. Develop national policies to support **well-funded, long-term national agricultural research systems** (NARS), including training of graduate students.
6. Develop mechanisms to **coordinate and enhance the marketing of horticultural products** from smallholder growers.
7. Create incentives and an enabling environment to **develop horticulture-oriented business services**.
8. Develop policies to **facilitate the participation of indigenous peoples, smallholders and women in value chains**.

1. INTRODUCTION

Since the mid-1980s, USAID has made significant investments in Latin America and the Caribbean to develop the export of horticultural crops, including investments in production, pest management, postharvest handling, processing, marketing, and value-added product development. As a result of these investments, the export of high-value crops and value-added products has generated a greater volume of international trade and contributed to a growing percentage of GDP. This has resulted in greater opportunities for producers and other agricultural enterprises to generate jobs.

With the adoption of free trade agreements between countries in the Central American region and the United States, there is an urgent need to improve the competitiveness of smallholder farmers. Access to finance, suitable land, markets and market information, technical assistance, input providers, research services, production technologies and sustainable cropping systems (including best strategies for pest management) are required to operate effectively and contribute to competitiveness of smallholders. In addition to increasing the opportunities for smallholder farmers to export horticultural crops, improving horticulture along the value chain can benefit domestic markets. Because horticultural crops are nutritious and a critical part of a balanced diet, increased production and consumption of these crops also benefits Central American consumers.

Horticulture is the science, technology, and business involved in intensive cultivation of plants for human use, including fruits, vegetables and ornamental plants. Horticultural value chains are complex, regardless of which country or specific product is considered. The different links in the horticultural value chain, and the impacts of different actors (producers, service providers, input suppliers, researchers and extensionists, buyers, consumers, and regulators) on the production and flow of horticultural crops to diverse markets (informal, intermediary, formal markets, and processing) influence benefits and benefit sharing among stakeholders. Different markets require different levels of sophistication in presentation and quality of the product, with informal markets being most tolerant in terms of product quality and presentation. The effectiveness and efficiency of the value chain to benefit different links of the chain, requires a degree of coordination, transparency, flexibility, and shared goals. It is clear that if one or more links are either inoperative or absent, the chain will not function effectively.

Producers must respond to the demands from regulatory agencies, the pressures of service providers (i.e. selling chemical inputs), the volume and quality demands of end users (i.e. formal markets, domestic and export), and the perishability of their commodities. Under such pressures, small-scale farmers are particularly vulnerable because of low bargaining power, lack of technical knowledge, and difficulties accessing capital. Therefore, special attention is needed to support smallholder farmers and provide the tools and enabling environment necessary to facilitate access to the economic benefits of profitable horticulture.

The assessment conducted in Guatemala and Honduras focused on identifying the kinds of constraints (economic, physical, biological, policy, training and technical capability) that affect the horticultural value chain; recognizing their effects on productivity, product quality, and therefore profitability; and identifying what is required to achieve sustainable growth of the horticultural sector.

This report focuses on the opportunities and threats related to fruit and vegetable production and marketing in the region, and the capacity of local institutions to conduct appropriate horticultural research and training to address the challenges.

1.1 CONTEXT

Economic investment for agriculture declined significantly in the last 20 years (Cleaver 2012). Since the food price crisis in 2008, there has been a rebound in interest from both donors and developing country governments in agriculture as a vehicle to reduce poverty and increase food security.

High-value horticulture is consistently more profitable than alternatives. Basic grain production by small-scale growers is less profitable than cultivation and marketing of high-value crops. For example, fruit and vegetable producers in India generate five to eight times more in profits than cereal farmers (Subramanian et al. 2000). In Kenya, farmers producing fruit, vegetables or flowers for export can earn six to twenty times more than maize growers (Gabre-Mahdin and Hagglade 2003; Minot and Ngigi 2003). Horticulture creates more jobs and produces higher income, but at the same time is more demanding in technology, infrastructure, pre- and postharvest management, finance and knowledge.

High demands of food safety and quality (from both consumers and regulatory agencies) impose stringent standards for growers and other value-chain participants to deliver a competitive product. With the pending implementation of the Food Safety Modernization Act, those requirements will become more stringent.

Changing the agricultural focus of smallholders from basic commodity crops into horticultural crops or mixed cropping systems requires that proper technologies, research and extension support, finance mechanisms, and markets be developed and accessible. Whether the right technologies required along the value chain are available in any particular country depend on whether that country has a technology adaptation, generation, and transfer system that is focused on addressing the constraints that reduce the productivity and quality of horticultural crops (fresh or processed) in horticultural value chains. In turn, the ability of small-scale producers to adopt and successfully apply improved horticultural technologies will also depend on the overall enabling environment for innovation, investment in, production of, and trading of horticultural crops.

Globally, horticulture research has received very little attention. However, the emphasis of the Feed the Future initiative in Guatemala and Honduras is on diversification of smallholder cropping systems toward increased production, postharvest handling, value-added processing, and marketing of horticultural crops.

The weaknesses in agricultural research and technology transfer capacity within Central America are well recognized (Segura Consulting LLC 2011), as are constraints to conducting agribusiness in the region. The objectives of this assessment were to identify specific constraints and opportunities, to assess local capacity to carry out horticultural research within the region, and to prioritize research needs for the horticultural sector.

1.1.1 HISTORY, GEOGRAPHY, AND MARKETS

Military dictatorship ruled many countries in the Central American region during most of the 20th century. Civil wars within El Salvador, Guatemala, Honduras, Nicaragua, and Panama affected economic development and the business environment, leaving a legacy of poverty and migration. The wars ended in the 1990s, paving the way for economic recovery and development in the region. However, natural disasters like Hurricane Mitch in 1998 delayed progress of Honduras and Nicaragua. The region is regularly exposed to hurricanes, which affects infrastructure and hinders agricultural development in the region.

The Central American Common Market was established in the 1960s; however, economic cooperation among Central American countries lacked dynamism because of conflicts, violence, military uprisings, and human rights violations that prevailed until the 1990s. Since the conflicts in the region ended, the Central American Common Market is becoming an instrument of economic development for the region. However, despite the economic liberalization and evident recovery in many countries, poverty and malnutrition prevail.

According to the Economic Commission for Latin America and the Caribbean, by the end of the past decade country level poverty was 67.5 percent in Honduras, 58.3 percent in Nicaragua, 54.8 percent in Guatemala, and 46.4 percent in Salvador—with poverty higher in rural areas (ECLAC 2011). Although poverty in the Latin American region has decreased, more that 167 million people still live under the poverty line.

The close proximity of the Central American region to its largest market, the United States, is a geographic advantage capitalized on by the countries in the region, particularly after the Caribbean Basin Initiative (CBI) and later the Central American Free Trade Agreement (CAFTA) which facilitated market access to the United States from Central America. Support from the United States and other nations, through international development programs, further invigorated the economy and boosted agricultural exports. Crops such as banana, sugar, coffee, rubber, cocoa and coconut were key crops in the region (and some still are the main exported crops), but exports of non-traditional crops are growing in several countries, including Guatemala, Costa Rica, Honduras, and El Salvador.

Climate change is expected to result in severe water shortages in eastern Central America, the plains, Motagua Valley, the Pacific slopes of Guatemala, eastern and western regions of El Salvador, and the northern, central, and western inter-mountain regions of Honduras (IPCC 2007). Effects of future climate scenarios on yields of maize and beans were recently studied by Schmidt et al., (2012) by downscaling global climate models to a local scale. The outputs of the downscaled models indicate that temperature is predicted to increase while precipitation will be slightly reduced. Soil water holding capacity and fertility conditions will be highly affected by climate change, reducing crop yield capacity by up to 50 percent under poor soil conditions.

Monterroso (2009) analyzed the land distribution in Guatemala, and indicated that, in 2003, (Censo Nacional Agropecuario, INE 2004) 45 percent of the farms had less than 0.7 hectares, and represented 3 percent of the country. Forty seven percent of the farms were between 0.7 and 7 hectares, representing 18 percent of the country. Only 8 percent had more than 7 hectares, but represented 78 percent of the national territory. An analysis of the census from Guatemala in 1950, 1964, 1979, and 2003 showed a trend towards smaller farm sizes in the country.

1.1.2 HORTICULTURAL PRODUCTION AND TRADE

Since the mid-1980s, the Central American countries and the Dominican Republic have embarked on agricultural diversification activities to offer non-traditional agricultural products to the market. Their goal was to focus production efforts to offer tropical and subtropical fruits to the export market. Fruit production accounts for 34 percent of the agricultural production in the region, and represents about $2.438 million. Between 2004 and 2008, the fruit export sector increased 48 percent. The main crops exported from the region are bananas (47.2%), pineapples (21.5%), melons (13.5%), juices and concentrates (7.6%) and other fruit derived products (4.3%). This growth in exports has occurred by targeting both intra-regional and international markets. Factors like the increased demand for healthy foods has helped to increase the market share of fruits and vegetables, and the increased per capita consumption of fruit in the region (111 kg/person/y) has boosted the intraregional markets. Within the region, Belize has the highest per capita consumption of fruits (260 kg/person/year), and the lowest is observed in Nicaragua (36 kg/person/year). Horticultural production in Honduras increased from 407,000 tons in 2004 to 500,000 tons in 2009 (23%) (FAOSTAT 2011). In Guatemala, total vegetable production grew from 1,110,500 tons to 1,639,600 tons (48%) during this same time period (FAOSTAT 2011).

In Central America, the majority of horticultural producers are small farmers, although some production is carried out by larger growers and companies. This is more evident in the case of vegetable production, where the normal size of a production operation is less than a hectare and in many cases less than an acre. Because of

Table 1a. Regional Vegetable Imports and Exports: Central America 2007-2009 (millions USD)

	Potato imports	Potato exports	Tomato imports	Tomato exports	Onion/garlic imports	Onion/garlic exports
Guatemala		4.8-12		2.1-6.3		2.2-4.9
El Salvador	4.9-12.6		10.7-15.8		1.9-4.5	
Honduras				1.3-4.2	0.1-0.5	
Nicaragua	1				0.5-1	0.2-1.2

Table 1b. Regional Fruit Imports and Exports: Central America 2007-2012 (millions USD)

	Banana imports	Banana exports	Citrus imports	Citrus exports	Melon/papaya imports	Melon/papaya exports
Guatemala		5.9-12.9	3.8-6			2.3-3.6
El Salvador	10.1-16.5		0.7-1.9		4.6-6.0	
Honduras	2.8-4.5			0.5-6.0		0.9-2.6
Nicaragua		1.8-4.3		3.1- 9.0		
Costa Rica		1.1-8	4.3-10.1			

(SEICA 2012)

the small size of individual operations, in Guatemala alone there are 50,000 small-scale farms involved in the export of vegetables. The top 20 (ranked by value) food and agricultural products produced in Honduras and Guatemala include a lot of horticultural crops. In Honduras, this includes coffee, bananas, tomatoes, oranges, pineapples, plantains, mangos, and guavas, and in Guatemala this includes bananas, coffee, tomatoes, melons, potatoes, pineapple, mangos, guava, avocado, and papayas.

Central America is a net exporter of fruits and vegetables. The trade of horticultural products is vibrant in Central America. The export of non-traditional horticultural crops such as snow peas and green beans has exploded in Guatemala in recent years, growing 541 percent between 1999 and 2008 (Feed the Future 2011). According to official figures from the Central American Economic Integration Secretariat, the total amount of vegetable imports from all origins was $145,359,389 while the total of exports to all countries was $302,489,934 (SIECA 2012). In the case of fruits, Central America imported $190,193,797 and exported $2,468,256,757 total.

1.1.2.1 NATIONAL

Small-scale fruit and vegetable farmers in Honduras produce mostly for local markets, be it supermarkets or wholesale informal markets. Internal market sales estimates indicate that the share of supermarkets in overall food retail is increasing rapidly, from 10 percent in the 1990s to between 30-40 percent by 2005 (Reardon et al. 2005). Wholesale informal markets still account for the majority of products sold domestically (USAID 2012). Such published information was not found for Guatemala or El Salvador. This “two-tiered” system identified by USAID, ACDI/VOCA and FHI 360 in a field report from 2012 highlights both opportunities and challenges within the Central American horticulture value-chain (Chalmers et al. 2012).

1.1.2.2 REGIONAL

There is an active trade of fruits and vegetables within Central America. Currently the region is the main commercial ally for Guatemala, followed by the United States and Europe (SIECA 2012). In general, trade statistics show that El Salvador is a large buyer of fruits and vegetables in the region, whereas Guatemala and Honduras, and to a lesser extent Costa Rica and Nicaragua, are key exporters of fruits and vegetables (Table 1).

1.1.2.3 EXPORTS OUTSIDE THE REGION

As for exports of fruits and vegetables outside the Central America region, Honduran smallholder farmers export mostly Asian vegetables as well as some fruits. In contrast, Guatemalan farmers export mostly snow peas, carrots and cucurbits, in addition to some fruits.

From 2001 to 2011, Central American countries have increased exports of fruits and vegetables to the United States, the main export market, at variable rates per year (1% to 11%). For instance, Costa Rica exported $621 million in 2001 and $1.012 billion in 2011, reaching a 5 percent U.S. market share of fruits and vegetable imports through pineapples, bananas, orange juice, melons, other tropical fruits, and preserved fruits/vegetables. The change achieved by Guatemala is even more striking, having export sales of $331 million in 2001 and $947 million in 2011. Guatemala currently holds a 4 percent share of the U.S. import market (bananas, pineapples, tropical fruits, preserved and frozen fruits/vegetables, melons, tomatoes, beans, and berries). Honduras is moving forward but more slowly, and exports to the United States increased from $165 million in 2001 to $293 million in 2011, holding 1 percent of the US market via bananas, melons, pineapples, cucumbers, beans (Johnson 2012).

The region is opening new market venues for fruits and vegetables as competition increases for the U.S. market. Exports to Asian countries and increased exports to Europe are being considered by large export companies in Guatemala.

1.1.2.4 EXPORTS OF PROCESSED FRUITS AND VEGETABLES

In the case of processed fruits and vegetables, in 2012 the Central American region imported $321,309,189 while it exported a total of $443,743,896 (SIECA 2012). Again, even in processed fruits and vegetables, the Central American region is a net exporter. However, more can be done in processed products as the difference between import and export is not as large compared to fresh fruits and vegetables.

In 2012, Guatemala exported to the Mercado Común Centro Americano (MCCA) about $331 million as food presented in diverse forms, and El Salvador and Honduras absorbed about 72 percent of these exports. El Salvador is not a fresh food producer, but clearly is becoming more focused on processing and exporting. Exports of juices doubled from 25 million tons to 50 million tons between 2004 and 2008. In January to October 2012, exports of processed fruits from El Salvador amounted to $59 million, 13 percent higher than in 2011 (PROESA 2012).

1.1.3 RECENT EVALUATIONS AND INITIATIVES OF THE HORTICULTURAL SECTOR IN CENTRAL AMERICA

Assessments of various aspects of the horticulture sector in Central America have been made over the last 20 years. Following is a brief summary of the key findings.

1.1.3.1 PICHA 1992

In 1992, Picha conducted an assessment of the needs of the horticultural sector and identified several issues within pest management, crop production and management, and postharvest technologies as the most limiting factors for growth of horticulture in the region. The study made specific recommendations on limiting diseases. The recommendations were supported by the experience of the author of the study, as well as a limited number of surveys. Specific recommendations included:

1. characterization and epidemiology of the sweet potato whitefly;
2. integrated pest management, with special emphasis on the sweet potato whitefly, viruses of melons and papaya, cherry mites, anthracnose on mango, root rot caused by *Phytophthora*, powdery mildew and fruit rot caused by *Botrytis*;
3. breeding for resistance to viruses on melon and papaya;
4. regulation of flowering and fruiting of mango;
5. storage and controlled or modified atmospheres during transport;
6. in vitro propagation of ornamental plants and tropical fruits; and
7. chemical residues and degradation of pesticides.

Picha focused mainly on aspects of crop production. However, the current vision indicates that the problems and solutions must be conceptualized at the level of the value chain, which includes other approaches and solutions as well as the purely investigative and technological. The problems identified by Picha still represent serious constraints, and with a level of relevance similar to 1992, although progress has been made in technologies and processes to tackle them.

1.1.3.2 GLOBAL HORTICULTURE ASSESSMENT

In 2005, USAID funded a study on the needs of horticulture worldwide. This assessment, led by the University of California, Davis and supported by Michigan State University, Purdue University, the University of Hawaii at Manoa and the World Vegetable Center (AVRDC), included a series of consultations in Asia, Africa and Latin America. Consultation workshops were held in the Central American region. This study clearly showed that it is not only essential to generate enough technical knowledge to develop the potential of horticulture to alleviate poverty, but that many other factors must act in synchrony to function efficiently and effectively in a successful horticultural value chain. The Global Horticulture Assessment emphasized the fact that research in horticulture has received little attention and international funding, despite its great capacity to alleviate problems of malnutrition, nutritional imbalances and poverty. The document called on the international community to fund research in horticulture, and especially to promote gardening as a vehicle to reduce rural and urban poverty. After the assessment, USAID initiated and funded the Horticulture Innovation Lab (as Horticulture CRSP) in 2009, but funding of horticulture research and development in emerging countries has remained limited.

1.1.3.3 REGIONAL PROGRAMS

In response to growing interest and opportunities identified by Central American countries to invest in the horticultural sector, several regional programs have been implemented in the last few years. The Mesoamerican Fruit Program (Proyecto Mesoamericano de Fruticultura) PROMEFRUT (2009-2011), a BID-supported initiative that generated Regional Public Goods was implemented by IICA, SECAC, OIRSA and OIMA. The objective of this program in its first phase was to improve the competitiveness of the fruit sector in Central America.

One of the products derived from PROMEFRUT was a regional agreement among the Central American countries to become competitive in fruit production and marketing. The regional agreement named PRO-FRUTA, promotes actions that will have better impact if applied regionally rather than on a national basis. The program described clearly the current challenges and instruments to overcome them, and identified six axes on which to focus regional actions and mechanisms.

- A1: Trade, promotion and market intelligence
- A2: Health, safety and quality
- A3: Promote competitiveness
- A4: Technological innovation and knowledge generation
- A5: Institutional strengthening and development of technical and business skills
- A6: Cross-cutting themes: risk management, environmental management, food and nutrition security and equity

PROMEFRUT generated action plans for market intelligence, knowledge generation and a health, safety and quality platform.

National programs to promote fruits and vegetables have been implemented as well. For instance, PROFRUTA increased areas devoted to fruit production from 2,500 hectares to 30,500 hectares between 1995 and 2004. The PINFRUTA program, a successor of PROFRUTA, increased areas planted with fruits by an additional 10,191 hectares from 2005 until 2011.

In 2010, an IICA study to prioritize fruits in Guatemala within a MAGA/PROFRUTA program used a set of parameters to assign weight to each fruit species. These parameters included: positive externality index (how good for the environment the crop is), potential to generate employment, potential for income generation (Qz/hectare/year), internal return on investment (TIR%), internal market Index (imports), potential for market diversification (how many countries import this crop), export value, and competitiveness of Guatemala producers. This methodology produced the following list of priority fruits for the country: papaya, lime, strawberry, avocado, plantain, rock melon, mango, macadamia, passion fruit and peach.

Two recent studies have evaluated USAID-funded aspects that are relevant to the horticultural sector in the region and specifically for Honduras and Guatemala. The first study by Segura Consulting (USAID 2011) provides a detailed look at the regulatory aspects of governance, financial, environmental (climate change), security and corruption, food security, competitive markets and infrastructure in Guatemala.

This study identified the following areas of high relevance to the sector:

- **Markets and competitiveness:** The report concludes that despite the success of Guatemala in export markets, it is essential that the country develop skilled labor by offering training and education opportunities and offering competitive and attractive salaries.
- **Finance, credit and investment:** Guatemala still suffers from supply and demand for finance which affects mostly smallholders in the coffee and horticulture sectors.
- **Climate change and environment:** Lack of attention from the government of Guatemala to environmental issues affects agriculture and agribusiness, resulting in high opportunity costs.

- **Infrastructure:** The country requires large investments in physical infrastructure (small- and large-scale), which could be implemented through public-private partnerships.
- **Security, crime and corruption**: Lack of security in the country increases production costs and discourages investors.
- **Policy and enabling environments:** Past policies have not been very conducive to a growing agribusiness sector.

The second report was based on Honduras, where the Inter-American Development Bank (IDB 2010), identified a number of issues for the horticulture subsector that undoubtedly apply to other countries in the region, including concentration of market power, as markets are dominated by a handful of buyers. Access to credit was also identified as difficult, in part due to massive debt forgiveness programs that were implemented after Hurricane Mitch and to the fact that producing and marketing perishable products entails a high risk, particularly when that is combined with a weak support infrastructure. Access to credit has improved with the help of the Millennium Challenge Account having established an agriculture program that included credit as a main component. An estimated 5,317 horticultural producers were reported to have access to credit. However, it is also true that of these, an estimated $2.2 million in outstanding loans were reported at the time this report was published in 2010.

Another recent study, "Sustainability in Honduran Informal Market System" (Chalmers et al., 2012) evaluated the performance of informal markets in Honduras, how these relate to the producers, and the types of services established by middlemen. The study highlights three main findings:

- Producers that received technical assistance or were engaged in a calendar planting program had the highest likelihood of selling to formal markets, and the highest income per crop/per season.
- To reap the benefits of market access, farmers need to be organized into groups to enhance their negotiation power.
- About 80 percent of smallholders sell to middlemen because they pay cash at the time of sale.

Closing gender gaps and empowering women contribute to improving productivity, increasing efficiency in agriculture, reducing hunger, and achieving food security (FAO 2011). To measure women's empowerment, the Women's Empowerment in Agriculture Index (WEAI) was created in 2012. The WEAI is a tool that measures women's control over their lives in five domains and is based on the Alkire Foster Method which can distinguish between empowered and disempowered people (IFPRI 2012). The WEAI is robust enough to measure changes in empowerment in both men and women over time. It will be used by USAID to measure the impact of development programs on women's empowerment. To develop and verify the WEAI, an extensive pilot study was completed in several countries, including Guatemala. The data from Guatemala illustrate the levels of disempowerment for women in agriculture.

In the Western Highlands of Guatemala, the study indicated that women are less empowered in agriculture than men. In the study, (237 women and 197 men) women were less empowered than men. Only 28.7 percent were empowered compared to 60.9 percent of men. Analysis showed that the areas that contributed most to the disempowerment among women were the lack of leadership in the community (23.7%) and control over the use of household income (23.7%). Women were not empowered, and they lacked access to credit and the ability to make decisions about it. The factors that contributed to men's disempowerment were similar to those encountered by women. However, the lack of control over income was less important for men, but lack of control over resources had a heavier weight for men. The study also showed that age was highly correlated with empowerment. Women below the age of 26 and in the age group of 56-65 were less empowered as compared to other age categories.

Similar conclusions were reached by a group of 85 women that participated in the "First Conference of Female Horticultural Producers in Honduras 2012." This initiative was led by Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) working in Honduras, Rural Competitiveness Project (COMRURAL), National Program of Food and Agriculture Development (PRONAGRO), Secretary (Ministry) of Agriculture and Livestock (SAG), DICTA, and the Honduran Council of the Economic Sector (COHDESSE).

1.2 OBJECTIVES

Our objective was to assess the capacity of the horticulture sector and support organizations in the region to respond to the following questions and needs:

1. **Constraints:** Which issues related to pests and diseases, crop varieties, fertility, cultural management, postharvest handling, value-added processing, marketing, and/or other constraints (e.g., land tenure) currently reduce either: (a) the quality, productivity, profitability, and income-earning potential of horticultural crops or (b) the ability of a country's horticultural industry to grow on a sustainable basis?

2. **Opportunities:** What are the opportunities for improving income through production of new crops, adoption of improved technologies or varieties, creation of new value chains, and development of new methods for adding value to horticultural crops?

3. **Technologies:** To what extent are on-the-shelf technologies available, appropriate for, and transferable to small-scale producers to address the constraints these producers face?

4. **Research:** To what extent is ongoing research and local capacity to carry out research and training on horticultural crops able to address the constraints that most threaten the ability of a country to grow its horticultural sector and, more specifically, the ability of small-scale producers to profitably and sustainably compete in a country's horticultural industry, especially factoring in climate change? What are the research priorities to address these needs?

2. METHODS

The methodology (Figure 1) used to conduct this assessment of the horticulture sector in Central America consisted of:

- Background research and literature review, including a document review
- Interviews and field visits
- Analysis
- Consultation workshops
- Web survey
- Analysis
- Dissemination workshops
- Final report and dissemination of results

The study was conducted between October 2012 and March 2013 in Guatemala, Honduras, and El Salvador.

2.1 INTERVIEWS AND FIELD VISITS

From October to December 2012, the assessment team visited El Salvador (Oct. 25-26), Honduras (Nov. 11-23), and Guatemala (Dec. 1-15). In Guatemala and Honduras, interviews involved visits to different regions of each country, while in El Salvador interviews were only conducted in San Salvador. In total over 190 individuals were interviewed for this report. At each visit, various actors of the horticultural value chain participated in semi-structured interviews to obtain their views on challenges and opportunities for the horticultural sector. Interviews were conducted with individuals or with groups of 2-10 people representing their organizations, including men and women. Each interview took at least an hour, but occasionally extended up to three hours. There was no specific set of questions used for each interview, and the interviews were open-ended. Interviewers took notes during the interviews and, when given permission to do so, the conversations were recorded and later reviewed by the team. Individual farmers (small and large), researchers (national level, universities, and private sector), NGOs, Ministers and ex-Ministers of Agriculture, wholesale buyers, and heads of farmer organizations and cooperatives all participated in interviews. A detailed list of organizations interviewed is presented in Appendix A.

2.2 CONSULTATION AND DISSEMINATION WORKSHOPS

Two types of workshops were conducted during the assessment: consultation workshops and dissemination workshops.

Consultation workshops: The first workshop was held in Comayagua, Honduras, on Nov. 15, 2012. A second workshop took place in the city of Antigua, Guatemala, on Dec. 6, 2012. Approximately 35 people were invited to each workshop from an extended list of stakeholders; those invited to participate were selected based on the sector they represented, their history and leadership in the horticultural sector of each country, and their capacity to contribute significant information on the challenges and opportunities facing the horticultural sector in Central America. Workshop registration was through the Horticulture Innovation Lab website. The value chain links represented at the workshops included production, postharvest, processing,

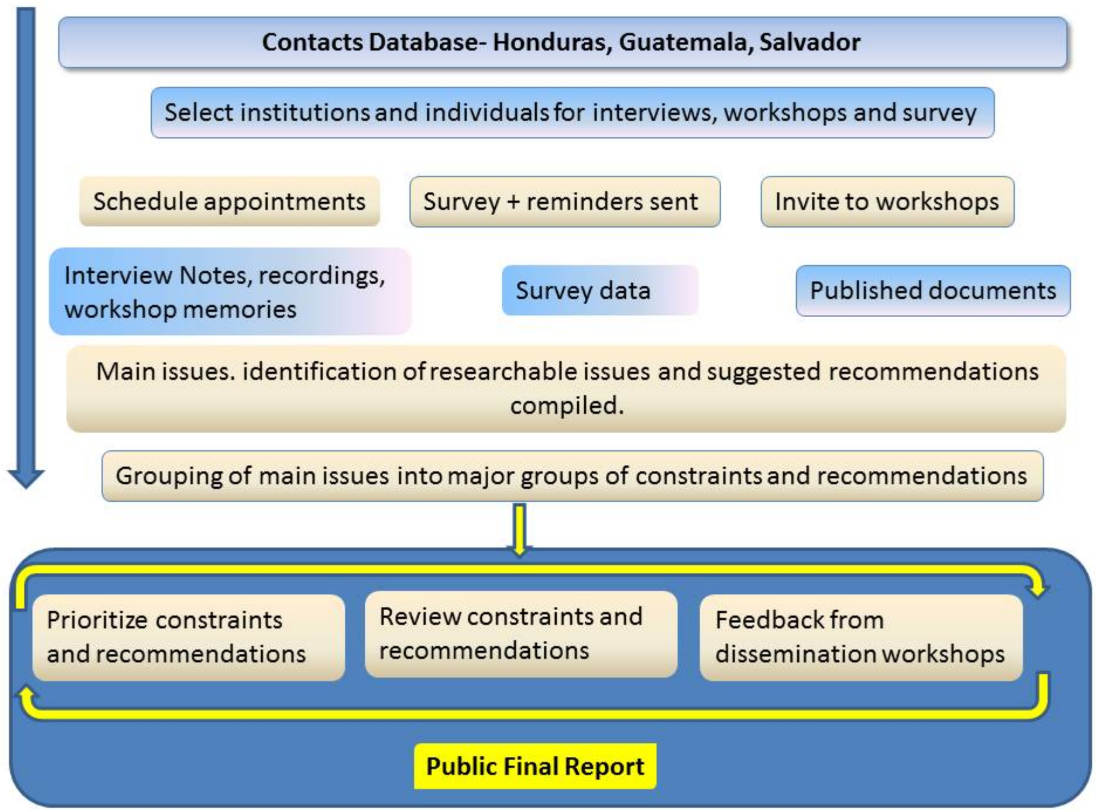


Figure 1. Information flow and analysis of the in-person interviews, workshops and survey information.

marketing, technical services, business development services, international aid, NGOs and government regulators.

Each workshop was divided into two sessions: Session 1 included 15-minute presentations by the assessment team, followed by five presentations from workshop participants. Session 2 included discussion tasks suggested by the assessment team; workshop participants were randomly assigned to groups of 3–5 people. Group discussions happened both in the morning and in the afternoon.

Task one (morning): Workshop participants were divided into groups to work on three tasks:

1. Identify issues and needs of the horticulture sector (production, postharvest management and processing, input providers, availability and quality of technical assistance, traders, and access to formal and informal markets).

2. Identify at least five needs per link in the horticulture value chain and suggest how to address those needs.

3. Sort those needs in order of priority.

Task two (afternoon): Working in small groups, participants were asked to answer two questions:

1. What alternatives and approaches are needed to make small- and medium-size farmers more competitive in a globalized economy?

2. How can we prepare the horticulture industry for the challenges coming in the next 10 years?

Each group reported back to the plenary for an open floor discussion of their findings and recommendations. Each workshop was supported by a note taker.

Dissemination workshops: One-day dissemination workshops were held at the FHIA facilities in La Lima, Honduras, on March 11, 2013, and a second dissemination workshop was held in Ciudad Antigua, Guatemala on March 13, 2013. In these workshops, the assessment team shared information about the main findings of the evaluation, i.e., the limitations that prevent the development of the horticultural subsector and recommendations to meet those challenges. For these workshops, those invited to participate were selected considering their position to influence change in the sector they represented, as well as their history and leadership in the horticultural sector of each country. Participants were asked to form groups to discuss the recommendations that the evaluation team decided needed more feedback from the various stakeholders in the sector.

The groups were asked to provide answers to the following questions:

1. What other actions would you suggest to address the constraints in the horticulture value chain?
2. Choose the two most important actions, according to impact and feasibility, to address those constraints.
3. Tell us how those actions could be implemented, who is responsible, and who should be involved in implementing the actions.

During the workshop in Honduras, groups were asked to work on production, postharvest, processing, and marketing. In Guatemala, groups were asked to work on gender constraints, training and education, and research. Each group worked on a single constraint type, and reported back to the plenary for an open floor discussion. The workshops were supported by a note taker.

2.3 SURVEY

A survey was prepared and distributed online to a wider audience to gather a broader perspective about the horticulture sector in Central America and to rank the constraints previously identified as to their importance. A pilot survey, prepared in Spanish, was given to eight people and then refined before being sent to participants. The survey, prepared and implemented using an online survey tool (SurveyMonkey), was sent to an initial list of 240 players in the horticultural sector in Central America representing Honduras, Nicaragua, El Salvador and Guatemala. The survey was also sent to those who participated in the interviews and workshops, other actors that were suggested during the visits, and others suggested by those who responded to the survey. The survey was distributed electronically in early February 2013 and remained open for 30 days. Email reminders were sent twice during that period to recipients to encourage survey response. Of the 240 people contacted 70 responded and completed the survey, giving a response rate of 29 percent. The survey (see Appendix C) included questions intended to highlight specific limitations throughout the value chain, and to prioritize research needs.

The survey had three sections, and participants could answer one, two or all three sections. This option offered the flexibility of preparing a single survey, instead of three, and allowed participants to respond only to the sections they felt most relevant to their situation. In the first section, the participants provided basic information and were asked to rank various issues from "not limiting" to "extremely limiting" to the horticulture sector. The second section had questions related to markets, and the third section targeted research issues. The issues included in the survey resulted from issues mentioned and ranked as important

Table 2. Constraint type and description of issues mentioned in the interviews and workshops

CONSTRAINT TYPE	DESCRIPTION
Biological	varieties, pests, diseases
Cultural	spacing, pruning, soil management
Food safety	microbial, chemical
Education/Training	access to information, knowledge, university capacity, technical assistance
Economic	financing, input costs, market prices, profitability
Engineering/Technology	irrigation, cooling, processing
Management	budgeting, planting choices and schedules
Physical	climate, soil, nutrients, water, rain, relative humidity
Policy	private or public regulations, actions
Social	gender equity, land tenure, social norms, cooperatives

during the consultation workshops. Questions in the research section included questions that were considered by the Picha (1992) study, plus additional ones generated during the workshops and interviews.

2.4 ANALYSIS

More than 190 people participated in person for interviews and workshops. The composition of participants included a broad range of organizations and stakeholders from within the horticulture value chain, including producers, development practitioners, government representatives, service providers, researchers, educators, marketers, financers and consultants. This assessment uncovered a broad variety of challenges for the horticulture sector; in order to focus the results, a number of strategies were used to identify the most pressing issues.

The evaluation team consolidated the interview notes and conclusions from the workshops, and verified these by reviewing the recordings as needed. The comments made by interviewees were organized by actor or link in the production chain and constraint type (Table 2). The interview text was coded by constraint type (biological, economic, policies, engineering and technology, education and training, crop management, physical, and social); some categories were suggested initially by USAID and from the research team's experience. Within these constraint types, topics were subsequently pooled to capture what respondents expressed as challenges or opportunities for the sector. To develop a mechanism for focusing recommendations, identified problems were prioritized by answering questions such as: If this problem is solved, what may be the impact on the sector and poverty alleviation? Is the solution to this problem long-term or short-term? By answering these two questions, we were able to better understand the importance of a solution in terms of economic impact and scale.

Seventy people responded to the online survey. Respondents represented mostly Honduras (42), followed by Guatemala (24), El Salvador (3), Costa Rica (1) and the United States (1). Eleven women and 59 men responded to the survey.

To analyze the results of the online survey, participants were grouped into one of five industry types based on their responses to the questions: What is your profession? What type of organization do you work for? What area do you work in? The five categories identified were: academic (11), extension (14), government (8) (this group includes those working for their own government or representatives of foreign governments, i.e., USAID staff), grower (10), grower-academic (6) (these individuals worked for academic or research institution but also heavily identified as a producer/grower), and the private sector (18).

All respondents indicated they had a professional degree. Fifty six percent were agronomists, 21 percent economists and administrators, and the remaining 23 percent represented other disciplines (education, biology, biochemistry, industrial engineering, and rural development).

Similarly, when asked what area of the value chain they felt more affiliated with, 45 percent work on production, 21 percent on marketing, 26 percent on research, 18 percent as consultants, 32 percent as extension agents, 13 percent in education, 2 percent from government, 4 percent as input providers, and 12 percent said "other." Multiple responses were permitted. Only 18 percent were most affiliated in a single area, 23 percent in two areas, 16 percent in two areas, 10 percent in four areas, 3 percent in five areas, and 1 percent in all six areas (a commercial laboratory). Out of the 26 people involved in research, 13 were also considered to be involved in extension services.

In both Guatemala and Honduras, 62-65 percent of the people who responded to the questions in the research section were in the field of integrated pest and disease management, followed by crop adaptation to protected agriculture (high tunnels, greenhouses, etc.)(48-57%) and crop management (agronomy and physiology) (48-57%) (Appendix C, Question 14). The lowest representations were in the fields of sociology and rural development, agricultural economics, and policy development, biotechnology and food engineering (16-27%).

3. RESULTS

In the online survey, respondents were presented with three sets of questions where they were asked to rank different factors within each section from not limiting (1) to extremely limiting (5) to the horticulture sector. These sections were production, markets and policy, and climate. All four of the most limiting factors were identified within the markets and policy section; this section was also ranked with the highest average for limiting factors 3.6 compared to 3.3 (production) and 2.9 (climate) (Table 3).

Table 3. Top 10 barriers to horticulture production

Barriers as highlighted in the survey (Summary statistics)	Overall averages*
Access to credit for small producers	4.32
Cost of credit for agriculture	4.23
Cost of agriculture insurance	4.11
Availability of agriculture insurance	3.99
Access to export markets	3.97
Cost of irrigation technologies	3.90
Lack of government programs to support small producers	3.83
Public irrigation district	3.79
Cost of chemicals	3.78
Increased pest populations and diseases	3.76

*Scale of 1 (least limiting) to 5 (extremely limiting)

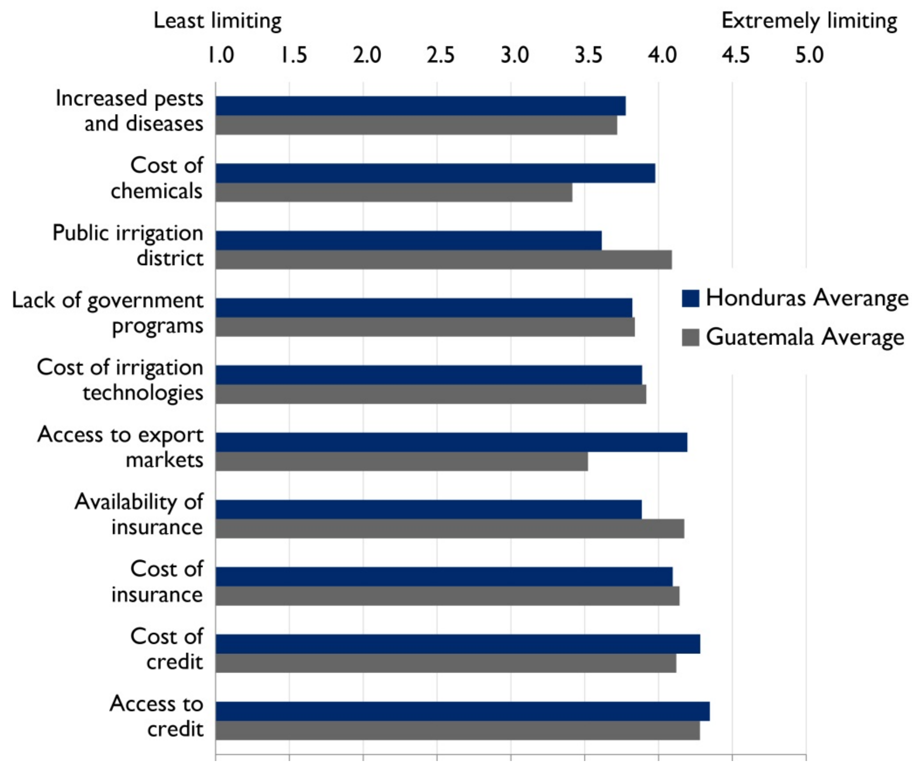
When these results are combined with what was learned during the in-person interviews and workshops, we see a number of parallel constraints. Economic issues include: access to and cost of credit, lack of working capital, little access to markets (more specifically formal markets) and access to and cost of crop insurance. Training and education related barriers also were highlighted as major barriers to the sector. Quality technical assistance, access to research results, extension services, and access to technical information were the most cited examples. The other main constraints identified were biological in nature: pests and diseases, lack of quality planting materials, seeds, lack of or costly biological inputs. Other related concerns came from those quite concerned with changing climate and the possible impacts of this on their production; access to water and irrigation as well as the changing pest and disease profile in specific regions. These three challenges—economic, educational, and biological—represent a broad spectrum of the issues faced by players in the horticultural value chain in Guatemala and Honduras.

While social issues related to under-represented groups were not fully explored in the survey, they were highlighted in the interviews and workshop sessions. Women consistently lack representation and have trouble accessing technical and other services. While access to and cost of insurance and loans were highlighted generally, these tend to be even more challenging to access for women and disadvantaged groups. Technology needs in both production and postharvest were highlighted especially during the interviews; smallholders are unable to invest (or get loans), and there is limited availability of new technologies in markets. Interestingly during the interviews people commented on weak rural health programs, noting that these programs have not been effective in encouraging people to change their diets towards more nutritious foods. Creating new demand for micronutrient-rich fruits and vegetables is key to improving the sector overall.

The major constraints to the horticulture sector identified in this study were remarkably similar between Honduras and Guatemala (Figure 2). This was true of both the survey and the individual interviews. This shows that the challenges faced by the sector are very similar between the two countries with a number of key differences which will be discussed below.

The research capacity of local universities and research institutions was consistently identified as a major limitation to the growth of the horticulture sector. The interviews revealed that there seems to be little connection between research and practice, while in the survey researchers selected results getting to the end user as one of the main factors important to their work. The other critical factor was the availability of funds for research. Within the region many faculty members are teaching and not conducting research, and those who are able to do research are in underfunded labs, in universities that lack infrastructure. All of these challenges were highlighted by groups from both Guatemala and Honduras.

Figure 2. Top 10 barriers to horticulture production, with responses by country



The survey included a set of questions related to specific research needs. The surveys asked respondents about research needs within four broad categories: management of pest and diseases, crop production and management, biotechnology, and postharvest.

The most important themes under pest and disease management were IPM (96%), followed by development and marketing of biological products (70%), and identification and management of viruses (50%). The interest in development of biological products was confirmed in questions related to the focus on biotechnology, where more than 80 percent of respondents indicated that the utilization of microorganisms to control pests and diseases should be a priority, followed by adaptation of tissue culture technologies for low-cost use.

The most important themes to research under crop management were management of integrated production systems and crop management under protected agriculture. Following those, developing new varieties adapted to climate change, sustainable production systems and the availability of certified planting materials were the main management-related research needs.

The most important research themes under postharvest research were related to handling, including cold storage, quarantine treatments, pre-harvest crop management to optimize postharvest quality, and ensuring safety and establishment of maximum residue limits (MRLs).

4. MAJOR FINDINGS AND CONSTRAINTS

The complete list of constraints identified during the interviews and workshops is presented in Appendix B and summarized in Table 4. The assessment team recognizes that all constraints need to be addressed for the horticultural value chain to operate effectively and achieve its goals. Nonetheless, because recent documents had addressed similar constraints, this discussion mainly focuses on those identified during the interviews, not in background reading.

Table 4. Summary of key constraints to growth of the horticulture sector in Central America

	Key constraints	Details
Access to inputs	High cost	farmers cannot invest in needed inputs
	Genetic resources	lack of germplasm for commercial species
		native species can be pushed out by newer varieties
	Water	lack of availability in dry months (Nov-April)
		lack of new technologies, investment in
		lack of any technology or inefficient
Production	Pests and diseases	losses and market rejection
		vegetative materials often infected with viruses
	Food safety (FSMA)	lack of knowledge
	Climate change (resiliency)	lack of new varieties resistant to abiotic or biotic stresses
		changing climate zones within the country
		farmers lack the ability to adapt and make changes and they can be displaced
		need to adapt to new pests and diseases
	Technology and supplies	small farmers are unable to invest or get loans
		lack of infrastructure
		too expensive, not affordable
	Crop insurance	does not cover climate-related events
		difficult to access, especially for small farmers
Postharvest	Lack of technology	small farmers are unable to invest or get loans
	Processing	lack of innovation
		cheaper to import processed produce
		high production costs for processing industries
		low technical and business capacity
Markets	Access to markets	dumping by other countries (seed and product)
		little border control
		wholesale markets disadvantage small farmers (no direct sale opportunities)
	Access to credit	large buyers lend money and charge high interest (30%)
		very slow to get loans through appropriate channels
		few banks provide agriculture-related loans
		farmers have little collateral, especially women and minorities

	Lack of understanding of market needs	small farmers are unable to understand or get information on current market trends	
		little info on quality standards	
	Weak organizational structures	lack of transparency	
		price volatility	
		few contracts to hold parties responsible	
Research education and training	**Low level of education**	growers lack technical capacity	
		students lack interest in studying agricultural sciences	
		few institutions offer Master's or Ph.D. programs	
	Research capacity of universities and research institutions	little connection between research and practice	
		Honduras	lack of research funds
			poor infrastructure at universities
			horticulture faculty are teaching, not doing research
			some researchers have political ties and move in and out with each administration
			researchers do not reach out to producers
		Guatemala	lack of research funds
			research by students not necessarily focused on farmer needs
			funds are for teaching not research
	Extension services	delivered by private sector or NGOs, they lack trust	
		unreliable and transient people	
Socioeconomic	**Lack of opportunities for women**	lack of representation	
		few female extension agents	
		unable to get loans	
	Lack of opportunities for indigenous peoples	land tenure	
	Weak rural health programs (nutrition)	export oriented horticulture has not been shown to improve nutrition or change diets	
		increased production of horticulture crops does not equate to increased consumption	

4.1 BIOLOGICAL

4.1.1. PESTS AND DISEASES

Pressure from pests and diseases is a major concern in the region—even more now that new regulations under the U.S. Food Safety Modernization Act will soon be implemented—and will be especially relevant to export agriculture. The Central America region is already facing several catastrophic diseases, such as Huanglongbing (HLB) in citrus, Lethal Yellowing in coconuts, *Fusarium oxysporum* race IV in bananas, *Fusarium spp.* in pineapple and *Tuta spp.* in tomato. These pests and diseases already represent major challenges for small and large farmers including considerable economic damage. For instance, commercial production of citrus in Belize has been abandoned because of HLB.

When pests affect their crops, farmers absorb severe losses, face market rejections, and consequently suffer restricted market access due to previously unforeseen pest problems in their crops. To avoid losing their crops, farmers in the region often rely on increased agrochemical use with subsequent increased risk of chemical residues that surpass MRLs. This touches on two limitations identified by the survey: lack of access to information on the Food Safety Modernization Act (FSMA) and the high cost of chemical inputs. Through our survey, growers ranked this high cost as their most limiting factor overall and all participants ranked this as the most limiting factor related to production. Although efforts to support export agriculture are on a larger scale and more visible, farmers not involved in export agriculture often feel unprotected, abandoned, and even more vulnerable. As a consequence, their use of crop protection agrochemicals can further increase, with possible health issues for local consumers, farmers, and the environment. The lack of biological control agents and skills for IPM and sustainable production practices intensifies these issues. In some cases, smaller farmers' crops are purchased by larger exporters who need to adhere to the FSMA. This emphasizes the importance of safe use of agrochemicals and safe handling procedures to prevent contamination. All of these issues touch on the identified lack of education and knowledge related to chemical use and export regulations.

Some examples of crops that face these constraints:

- In Honduras, some tomato growers indicated they were looking for new regions in which to grow their crop (plus alternative ways to grow it under protected cultivation) due to the high costs of growing tomatoes in the open field.
- The rambutan industry has good potential as a niche crop for export and local consumption, but is faced with large rejections due to the presence of scale insects on the fruit, despite considerable and costly efforts to wash them off the hairy fruits.
- The avocado industry also has great potential for the region. As is common in many developing countries, avocado seedlings are sold through non-certified nurseries, and commercial varieties are grafted onto rootstocks that are not resistant to important diseases such as *Phytophtora cinnamomi*.
- Expansion of the native fruit species, such as jocote (*Spondias purpurea*) in El Salvador, has been halted because of disease, most likely a phytoplasma (Palmieri et al. 1999).

There is an anticipated increase in the variety and severity of pest populations due to climate change; IPM researchers were especially concerned about the climate-related impacts on pest populations.

4.1.2 FOOD SAFETY MODERNIZATION ACT

The Food Safety Modernization Act (FSMA) was signed into U.S. law on January 4, 2011, and enables the U.S. Food and Drug Administration (FDA) to better protect American public health by helping to ensure the safety of the U.S. food supply. The focus is on prevention. One of the most significant changes that FSMA made to FDA's food safety authorities is in the area of imports. FDA will transition from its historical focus on catching food safety problems at the border to one that builds safety in throughout the supply chain from foreign producers to U.S. consumers.

On July 26, 2013, FDA issued proposed regulations related to imported food. Under the Foreign Supplier Verification Program (FSVP) for Importers of Food for Humans or Animals, importers would be required to perform certain risk-based activities to verify that food has been produced in a manner that provides the same level of public health protection as that required of domestic food producers (FDA 2013a).

In response to changes in the U.S. FDA's function and operation, new rules for imports to the United States are being implemented:

- **Importer accountability:** Importers now have explicit responsibility to verify that suppliers overseas have enough preventive controls to comply with food safety standards. This may include conducting a hazard analysis for every food they import and conduct activities (lot by lot sampling and testing, on site auditing, etc.) that provide adequate assurances that the hazards identified are adequately controlled.
- **Third-party certification:** The FSMA dictates that FDA could establish a third-party certification program that could certify that foreign food facilities comply with U.S. food safety standards. Exporting countries would adopt at least one of the certification programs, to be established by FDA:
    - Certification for known food safety risks
    - Voluntary qualified importer program
- **Authority to deny entry:** FDA will be able to refuse entry of food from a foreign facility into the United States if the facility or the country in which the facility is located refuses to permit entry of FDA inspectors to inspect the facility.
- **Capacity building of foreign governments with respect to food safety:** FDA is now responsible for capacity building of foreign governments and their respective food industries exporting to the United States in the areas food safety.

The implementation of the FSMA could have serious consequences for all produce exporters from Central America, but especially small exporters, or smallholder farmers who sell to exporters. While small farms averaging less than $500,000 per year in sales are exempt from the FSMA regulations, it is not clear if this exemption applies to small farms that export to the United States because most of their product is consolidated by the importer. The proposed rules for Produce Safety under FSMA (FDA 2013b) include regulations around agricultural water quality, use of animal manures, hygienic practices for farm workers, control of domesticated and wild animals, sanitation of farm equipment, and training of farm personnel. The regulations for agricultural water and hygienic practices create the largest challenges for effective implementation in Central America.

Importers that obtain produce from numerous growers should consider implementing a traceback system to allow problem farms to be identified quickly if a food safety incident occurs. Digital tracking and tracing systems are available that utilize RFID tags to capture the movement of produce from the farm to the packaging area to export.

4.1.3 GENETIC RESOURCES

Progressive farmers and those already engaged in commercial agriculture tend to have access to commercial varieties that are in high demand by buyers. However, there is limited access to a broad range of germplasm for commercial species. This limits the establishment of plantings of the most commercially appropriate varieties or the capacity to change varieties in response to new market windows, new product development, or climate change. Smallholder producers are at a disadvantage when it comes to accessing these newer varieties and others demanded by consumers. Market information is not readily accessible to these farmers and as such they are unable to respond to changes in buyer demand as fast as larger growers. A related issue is the lack of locally-produced potato seed. All potato seed in Honduras is imported from Holland or other countries.

For example, fruit and vegetables grown by small-scale farmers are less likely to have been selected for resistance to abiotic or biotic stresses present in Central America (especially fruit). Many current varieties were introduced into the region more than 30 years ago. Although some testing for disease resistance of commercial vegetable varieties is being conducted in the region (by FHIA in Honduras, and by the Horticulture Innovation Lab with Asian pepper and tomato varieties in Honduras and Guatemala), the testing is far from sufficient against a broad range of diverse pathogens present in the region.

Native plant species and traditional farming systems play an important role in food security and nutrition in remote communities (CGIAR 2012), plus these crops may have considerable potential for the development of niche products. Expansion of commercial agriculture could result in displacement and disappearance of native genetic resources (e.g., jocote, piñón, native vegetables). It was evident from our interviews that in some communities, with the arrival of commercial "exotic" vegetable production, farmers were less interested in native crops for cultivation, choosing instead to engage in contract farming.

4.2 NATURAL RESOURCES

4.2.1 WATER

Irrigation and irrigation equipment were regarded as highly critical for sustainable, successful and year-round crop production. Water availability for consumption and irrigation is an issue in the dry months in both Guatemala and Honduras (as well as in Nicaragua and El Salvador). Dry months are usually November to April, and if water were available through irrigation projects, then crop productivity would increase. The establishment of micro-dams or rainwater harvesting systems has proven very effective in several regions of the world (more recently in Nicaragua), and when implemented, farmers enjoyed higher yields, crop diversification strategies, and income alternatives during the dry months.

Capturing water during the rainy season and then pumping this water to fields would reduce the time farmers dedicate to watering their plots. Simple gas, diesel, and solar systems can very efficiently pump water from a storage pond or tank to fields. In areas of high vegetable production, such in Valle de Almolonga in Guatemala where more than 5,000 farmers cultivate vegetables in 500-hectare plots, water is available at their plots. However, some farmers used shovels and small buckets to irrigate their crops, using many hours of valuable time each day. In such locations, investments in pressurized water delivery systems would relieve farmers from the time- consuming labor of water fetching. When irrigation projects are implemented, the entire distribution system (from source to final use) must be analyzed in order to anticipate any gaps in both infrastructure and knowledge. The cost of irrigation technologies was a major barrier that the survey highlighted; overall it was the sixth most important barrier to horticulture production. Water management and irrigation "districts" were also highlighted as a concern; as with any shared resources, effective and fair systems and policies must be in place.

In addition to the availability of water for irrigation, the quality of available water is very important. The potential for contaminants in the water, either heavy metals or microbial pathogens, to come in contact with fresh produce during irrigation, application of pesticides, or washing produce after harvest is a concern for human health and market opportunities. The adoption of FSMA will enhance the importance of water quality. However, the issue of water quality or potential contamination of water was not highlighted by participants in the workshops or the survey. This highlights the lack of information and awareness of food safety concerns.

4.2.2 CLIMATE

Central America has been recognized as highly susceptible to variable weather-related events (excess or decreased rain; higher or lower temperatures). The Intergovernmental Panel on Climate Change indicated that some areas of the region would be subject to water shortages in coming years (IPCC 2007). These events affect agricultural production, soil fertility, flowering cycles, and increased vulnerability to pests and diseases. Small-scale farmers are the most at-risk population as their levels of resilience are low. Changes in rainfall and high/low temperatures will have a multitude of impacts on horticulture; some are anticipated, but exact changes and coping strategies are yet to be determined.

Due to changes in weather conditions, the probability is high that the severity and frequency of economic losses caused by pests and diseases will be exacerbated. Indeed, expansion of distribution ranges of pests has been documented in different regions of the world (FAO 2008). In drier and warmer years, the distribution range of pests expands to the highlands, exposing farmers there to new pests, e.g., fruit flies or la roya flies (Hughes et al. 2012).

"In Guatemala the climate has changed, and it is warmer nowadays; the West used to be colder and potatoes, broccoli, cauliflower were sowed. Today, in Chimaltenango we plant snowpeas and lots of tomatoes. Thus, the climate change has had some effects. In addition pests are becoming a problem. We used to say that whitefly could go up to some elevation because the cold weather would be barrier. In other words, whitefly would only be found up to 1,500 meters above sea level. Today, we see that this pest is found all the way up to 2,400 meters above sea level. On the opposite, *Paratriosa* came down. It has acclimated to warmer conditions."

GROWER & RESEARCHER, GUATEMALA

4.3 SOCIOECONOMIC

Throughout Central America there are a number of socioeconomic challenges whose consequences are the underlying barriers to the horticulture sector. The unequal distribution of wealth, educational gaps and lack of programs to support the smallest producers are a few examples of such factors. Access to markets, insurance and credit were some of the most discussed barriers in this assessment, and their importance will be further discussed below.

4.3.1 WOMEN IN HORTICULTURE

Many studies, including the Global Horticulture Assessment, emphasize that women are heavily involved in horticulture, but lack equitable access to many resources. These resources vary from land tenure to sociocultural constraints that limit their participation. Likewise, indigenous peoples are often at a disadvantage when obtaining resources or accessing markets. Because women and indigenous peoples comprise a large number of smallholders and the world's poor, it is important to include recommendations specific to these groups.

We found that women have little input or power when it comes to decision making in community organizations and in farmer organizations. Guatemala has one of the lowest rates of female representation in government, both local and national. There are only 7 female mayors, out of the 333 mayoral races held in 2011. In addition to the political process, women also have a hard time accessing technical and vocational training. Men often take the lead in managing small farms, and women provide much of the unpaid labor. The work of women in agriculture was considered invisible to one group interviewed; women have less access to land, relied on rented land to be able to cover the family needs and finances, and had limited access to finances. Past research by the Horticulture Innovation Lab (as Horticulture CRSP) and the University of Minnesota found that this was due in part to cultural norms around gender roles, and also due to a lack of female extension agents (Collinson et al. 2013).

Still, in some communities, families deny education to daughters, although programs such as SOS Family Strengthening in Solala are in place to reverse this tendency (SOS Children 2011). Although still far from being optimal, it is clear that women's organizations are involved in primary production, as service providers for seedlings, transportation, packaging, and marketing. To gain access to export markets, a group of 400 women in Guatemala formed a cooperative, Mujeres 4pinos, to market their produce through the export channels of the larger Cuatro Pinos cooperative. This is interesting given that companies who contract farmers for non-traditional exports (Asian vegetables) often directly contract with the male head of household; technical training is then offered to the men and not their spouses (Collinson et al. 2013).

4.3.2 INDIGENOUS PEOPLES IN HORTICULTURE

With regards to indigenous peoples (who comprise a large number of people in Guatemala), the government in Guatemala is making provisions so that they achieve land tenure. Access to land tenure can improve access to credit and provide incentives for making improvements to landholdings. For many small-scale farmers, Spanish is their second or third language and understanding complex market and agricultural information is nearly impossible. However, another challenge is the continual subdivision of land among family members making plots smaller and smaller.

4.3.3 ECONOMIC ISSUES

The high cost of horticultural inputs (fertilizer, irrigation equipment, chemical and biological inputs, sorting, packaging, cooling equipment, transportation, storage) negatively affects returns to the investment in the sector, making it less competitive. There is a large variation in prices of inputs in the region, which encourages the unlawful trade of fruits and vegetables from neighboring countries, where products are available more cheaply. This seriously and negatively affects local producers.

4.3.3.1 ACCESS TO MARKETS

For smallholders, accessing markets can be an immediate barrier to production and sale of crops. Lack of knowledge of current prices, market expectations, quality standards, and availability of reliable transportation all act as disincentives to production and expansion. The cost of fuel and truck use is often a barrier to accessing higher value markets for producers of perishable products.

Small-scale producers do not always grow what markets demand, especially with perennial species. Farmers do not always have access to good information on quality standards or market needs. This makes it difficult for them to sell their produce to larger farmers to satisfy export quotas. Those who identified themselves as a producer said that they sell to a broker because they have no other options and no access to other market channels. Others said that they had a direct contract with a supermarket. Given the rise of supermarkets in Central America over the last ten years it is not surprising to see these comments.

Market prices are difficult to convey to many growers. Several organizations collect market prices (i.e. FASAGUA and FHIA in Honduras) for some products, but this information requires processing, interpretation and effective dissemination. Additionally, this information does not always reach growers in a timely manner and decisions made after the fact could be detrimental to them economically.

Interviews with farmers often surfaced concern that they face "unfair competition" because fruit and vegetable produce imported (possibly illegally) from a neighboring Central American country is sold at lower prices. Farmers sometimes perceive these neighboring countries as providing subsidies for freight and/or local authorities not exercising adequate controls. In some cases, due to inadequate trade controls, trucks with horticultural cargo identified as in transit to another country is sold in the country through which they were supposed to only be transiting, at prices below the prevailing market rate.

We observed a prevalence of weak organizational structures and dysfunctional value chains with undefined rules and roles. There is a lack of transparency in the seller-buyer relationship, and breaches of contract are common by both buyer and seller. The interviews identified that a lack of quality standards, few contracts, little transparency, and limited knowledge of prices and information all feed into a system where the smallest farmers are at a consistent disadvantage. However, other recent research in Honduras has shown that these informal systems provide much needed cash to small-scale farmers and cater to the unpredictable nature of horticulture production (Chalmers et al. 2012). There have been cases where alliances were developed between buyers and sellers. The buyers provided demand calendars to growers, providing them an opportunity to grow for market needs. These comments highlight the two-tiered nature of the horticulture sector in Honduras and to a lesser extent Guatemala. Both formal and informal systems have advantages to producers and fill a niche for consumers.

4.3.3.2 ACCESS TO CREDIT

For smallholder farmers, accessing credit allows them to invest in new technologies, land, and labor to improve their production and income. Current systems in Central America are lacking, and few banks provide loans or credit specifically for agricultural purposes. Poor farmers also have limited collateral to offer and at times the only option is to engage in "under the table" deals that in the end often disadvantage the small farmer. It is especially difficult for women and minority groups to access credit.

The most limiting factor of the 35 presented in the online survey was "access to credit for small producers." Not surprisingly those identified as growers felt the most strongly about this particular limitation and ranked it more limiting than the other groups. The "cost of agriculture credit" was ranked next, with individuals working in extension ranking this the highest.

The high cost of financing constitutes a barrier to the development of horticulture. Loans for agriculture in Guatemala represent slightly more than 5 percent of loans offered by banks. High profitability in banking in Guatemala comes from charging for financial services and not from interest on assigned loans (USAID

2010a). There are diverse financial institutions in Guatemala that offer loans to growers and cooperatives, which handle more than twice the number of loans managed by the banks. Additional sources of financing for smallholders come from export companies, but the interest charged varies 4-5 percent per month (USAID 2010a). When they can be obtained, farm loans through some cooperatives reach interest rates up to 36 percent, which makes the sector less competitive. Farmers who grow beans, maize, sorghum, or potato and also women farmers are less likely to obtain loans. To fill this gap, large buyers and intermediaries take advantage of small-scale farmers' need for cash up front and offer them a high interest loan at the beginning of the season, then take the product and sales at the end of the season to cover the loan.

Banks have high requirements for loan approval; banks often put more weight on the value of collateral (generally urban properties) than of cash flow or profitability of a project, and this becomes a barrier to granting a loan to smallholders (USAID 2010a). Small horticultural producers have difficulty gaining access to low-interest credit lines established in the form of trusts dedicated to horticulture. Banks do not promote products from financial intermediaries, as they favor their own products at much higher rates.

As highlighted in the 2008 World Development Report, Agriculture for Development, these financial market constraints all too often depress productivity and incomes in the small farm sector. At first glance, the continuing relevance of these constraints may seem surprising given that we are more than a decade into the microfinance revolution, which in many instances has relaxed credit constraints, especially for women micro-entrepreneurs and others who lack conventional collateral assets.

According to the director of the BASIS Assets and Market Access Innovation Lab (AMA Innovation Lab), the problem rests in part on the mismatch between the core principal of microfinance (mutual responsibility for loan repayment by groups of geographically proximate individuals) and the reality of agriculture in which all individuals within a small area may simultaneously suffer losses (e.g., from a drought), meaning that mutual payment responsibility fails and lenders suffer considerable portfolio risk (personal communication 2013).

One promising approach to this problem is the interlinkage of microcredit with novel forms of agricultural index insurance that protect lenders—and borrowers—against the risk of simultaneous default. In contrast to conventional agricultural insurance, which has proven to be infeasible for small-scale farmers, index insurance makes indemnity payments based on the performance of an easily measured and verifiable index (e.g., weather conditions) that is correlated with average farmer outcomes. While index insurance and credit interlinkage is a work in progress, a number of microlenders worldwide are keen to harness it as an instrument that will allow them to offer credit at reasonable interest rates to underserved small farm credit markets. For such a system to work, cooperation between numerous sectors including input suppliers, insurance companies, and weather data systems is required. Horticultural crops present a unique set of challenges to the design of interlinked credit-index insurance contracts, but given the potential of these crops to boost small farm incomes, it is clearly time to invest in instruments that promise to relax the key economic constraints that hold back this sector.

4.3.3.3 CROP INSURANCE

Crop losses due to extreme events—either lack of rain, excess moisture (too much rain or flooding) unusually hot or low temperatures—are all common and frequent in Central America. Current climate change models indicate the high risk to which the area is subject and predicts water shortages in coming years (IPCC 2007). Small-scale farmers are the most vulnerable to weather-related events, but larger farmers can also be affected. The cost of crop insurance and its availability were the third and fourth most critical barrier to horticulture as identified through the survey. Strategies to minimize the risk might include planting a diversified group of species; however, such a strategy is less viable in those small areas dedicated to commercial horticulture, and even more so for farmers with scheduled deliveries to large buyers. The lack of adequate, easily accessible agricultural insurance products was mentioned during the in-person interviews and workshops, and was clearly marked as highly limiting in the online survey. The interlinkage of microcredit with novel forms of agricultural index insurance should be explored as a potential solution.

4.4 ENGINEERING AND TECHNOLOGY

Innovation is the key for agricultural development and is the source of economic growth, job creation, improved productivity, and competitiveness. A combination of effective research, education and extension programs are usually required, but not sufficient, to stimulate needed innovations (World Bank 2012).

4.4.1 PRODUCTION TECHNOLOGY AND SUPPLIES

The need for affordable production technologies was expressed by all groups during the interviews and in the survey. Horticulture can be very technology intensive, and without the availability of proper information and tools, farmers will continue with current practices. The high costs of inputs (fertilizers, agrochemicals, irrigation equipment, bio-pesticides, etc.), lack of services (i.e. reliable transport, tractors for land preparation, mechanized pruning, technical assistance), and pressure from pests and diseases contribute to high costs and reduced competitiveness.

Protected agriculture has proven to be highly effective and is in high demand as a suitable strategy to reduce pests and disease problems, increase productivity, improve production consistency, and improve water-use efficiency (USAID 2008). However, despite some efforts to generate knowledge on the management of crops under small, medium, and large tunnels by local tunnel-supply distributors, additional research and development efforts are required to speed mass adoption of this technology. A major barrier to technology adoption is the lack of incentives, credit and education for small farmers. Without these, farmers will have a very difficult time expanding their production or entering into new markets.

4.4.2 PROCESSING OF HORTICULTURAL PRODUCTS

In Honduras and Guatemala, very little innovation in product development was perceived during the assessment. New product development, in addition to primary production and packaging, should be promoted to capture more of the value of the horticultural value chain.

A small number of processing industries exist in Honduras and Guatemala, and those visited indicated that their utilization of local produce is low because imported, pre-processed materials are cheaper (e.g., tomato paste from Chile and the United States). This might indicate that local production costs are too high for processing industries, and/or that fresh market demands exceed current local production. In addition, processors may be reluctant to source produce from smallholders due to the effort required to ensure consistent product volume to meet processing demands. However, it was also clear that prices collapse during local harvest times, and fresh markets become saturated with crops such as onion, tomato, potato and mango. Therefore, promoting horticultural crop processing could represent a venue for reducing saturation of fresh markets, as long as production costs are competitive for the processing industries. By making more processing varieties available to farmers, the processing industry may grow.

Zamorano University in Honduras and the Instituto de Ciencia y Tecnología Agrícola (ICTA) in Guatemala have facilities and skills for processing and have developed protocols for processing local crops. However, business development skills would be useful to transform those experimental products into new commercial products, perhaps through private-public partnerships that benefit local communities. To promote innovation among growers of horticultural crops, knowledge of production practices, processing, and postharvest management of local species must be combined with business development skills.

4.5 RESEARCH, EDUCATION, AND TRAINING

4.5.1 EDUCATION AND TRAINING NEEDS

The lack of operational capacity among growers results in low-quality produce, low productivity, inadequate production practices, and reduced access to formal markets. Growers lack training in well-accepted best practices for horticultural crop production and handling.

There is a lack of connection between research projects conducted by local universities and agricultural issues affecting small-scale growers. Some universities have research facilities, but have very little access to funding, and research projects are conducted mainly through undergraduate students and international funds. Universities are focusing more on training students in business development rather than forming new researchers or extension agents. This approach has affected organizations such as ICTA, which relied upon students conducting some research as part of graduation requirements. Training of students with a proper balance and mix of skills, both business and technical, will be beneficial to Honduras and Guatemala, especially in promoting innovation.

It was striking how few institutions in Honduras and Guatemala offer advanced degrees (Master's and Ph.D. levels). This fact alone forces talented students to leave their home country if they want to pursue an advanced degree, reducing the chances that they will return to apply the knowledge gained to advance their country.

Since the elimination of agricultural extension services in the 1990s, technical assistance is mostly delivered by the private sector. The private sector offers technical assistance to growers under production schemes, funded by farmer organizations, through levies collected from sales, or through national and international NGOs. However, several producer organizations expressed their reluctance to accept the questionable quality and scant quantity of technical assistance offered by some NGOs. Occasional technical assistance is available through government programs when supported by international aid. When it exists, a single professional has to serve many farmers, sometimes at a ratio of 1:200. Such assistance disappears when the project ends. In 2013, Guatemala reinstated its extension service.

> **"There is a lack of education among service and input providers, and producers. Many products are sold without the exact knowledge of how to use it, its purpose, and the associated risks involved in handling these products. There is lack of control of agro-services. Products entering the market are not validated, are freely traded across the border, entering without any control.**
>
> **"Right now there is no formal technical assistance of high quality. The technical assistance offered by many NGOs is below standards because technicians do not have the experience or background to deal with problems in the production fields."**
>
> **PARTICIPANT IN WORKSHOP, HONDURAS**

The final section of the survey focused on research priorities and needs. The population surveyed had a variety of research backgrounds including IPM, agronomy, physiology, postharvest, and protected agriculture. Those involved in research were asked to look at a number of factors and assess their importance to performing their work. The most critical was that their work and the results of their research be transferred to the end user; this was followed by the availability of funds to carry out their research. Interestingly, stimulating innovation and addressing rural development issues were also selected as extremely important to their work.

The group was asked to identify research priorities in management of pests and diseases. The areas getting the most support (in terms of times voted for) were integrated pest and disease management, the development of biological control agents, the commercialization and accessibility of biological control agents, and lastly the identification and management of viruses.

Responses around research priorities for production and management were not all that varied, and our analysis didn't show much difference in the responses. Because participants could vote for as many research priorities as they wanted, only two stood out by just a few percent: integrated production systems and management of crops under protected structures (Appendix C for full survey). Participants felt that research priorities for biotechnology should focus on the development of low-cost tissue culture systems, the development of endophytic organisms to counter pests and disease and optimize transformation and regeneration protocols.

In postharvest research, the priority themes were postharvest handling of products indigenous to Central America with export potential, improved crop management to optimize postharvest quality and ensure safety, and defining MRLs for commercial agrochemicals.

4.5.2 RESEARCH CAPACITY OF UNIVERSITIES AND RESEARCH INSTITUTES

4.5.2.1 HONDURAS

Universidad Nacional de Agricultura (UNA). Located in Catacamas in the Olancho Department, UNA has two professors with Master's degrees working in horticulture, one in fruit crops and one in vegetable crops. The school also has field facilities to conduct applied horticultural research, where a germplasm bank for fruit crops is also located. There is a program on genetic resource conservation and the school leads a national network for germplasm conservation. Additionally, UNA has a food technology lab. The main constraints for doing research are a lack of funding and infrastructure. Faculty are involved mostly in teaching, though undergraduate students must write a thesis as a prerequisite to graduate, which could represent an opportunity for generating knowledge.

Escuela Agrícola Panamericana, Zamorano. Situated just 30 minutes from the capital city of Tegucigalpa, Zamorano has two faculty members involved in horticulture, one who has a Ph.D. working on vegetable crops and another with a Master´s degree working on fruit crops. The school has adequate laboratories and field facilities that include a biotechnology lab equipped with basic tools for gene analysis (polymerase chain reaction) and tissue culture. The school also has ample field facilities to conduct applied horticultural research. There is a food technology laboratory, both for student and public training. This is one of the most advanced laboratories for development of processed products (established under a USAID activity) and also conducts analyses needed for food nutrition labels. The faculty´s heavy involvement in teaching and, to a lesser extent, a relative lack of funds for research are the main reasons for not doing research, although some faculty are involved in contract research. Students work on theses as part of their graduation requirement, which represents an opportunity to contribute to horticultural knowledge. However, research by students is only one year in length and does not necessarily respond to the real needs of farmers. There is a perception by the public that Zamorano should reach out more to the national and regional community. The Horticulture

Innovation Lab recently funded its Regional Center at Zamorano, a center with a mandate for the entire Central American region.

Centro Universitario Regional del Litoral Atlántico (CURLA). This regional campus from the National Autonomous University of Honduras (UNAH) is strategically located in La Ceiba on the Caribbean coast of Honduras. The school has two professionals with Master´s degrees, one each working with fruits and vegetables. This campus hosts a germplasm bank for tropical fruit crops. Faculty members are involved in teaching, but not in research, even though students have to work on a thesis to graduate. Students have to not only find a research topic for their thesis and pay for their own research, but also secure a partner institution at which to do their research. Some of these host institutions help cover the research costs. Lack of funds and adequate laboratory and field facilities are the main reason for lack of research. Additionally, as a satellite campus of UNAH, CURLA does not have administrative independence and any interaction between CURLA and other parties for research must be negotiated with UNAH.

Dirección de Ciencia y Tecnología (DICTA). As the country´s national agricultural research institute, DICTA has modest research capabilities. There are three researchers with Ph.D. or Master's degrees working in vegetables, and one dedicated to fruit crops. This research institute has two tissue culture labs, one devoted exclusively to potatoes. DICTA has three applied research stations for fruits and vegetables with minimal infrastructure. Even though this national agricultural research institution has research capabilities, it does not receive enough funding. Additionally, there is a high degree of personnel rotation and trained researchers end up leaving the institution after a new political administration takes office. Another constraint for doing research is that there is neither planning nor focus of the limited resources to do research.

Fundación Hondureña de Investigación Agrícola (FHIA). A private research foundation started by a trust fund from USAID and the donation of research laboratories by Chiquita, FHIA is an institution that works on high-value crops. The foundation has five researchers with Ph.D. or Master's degrees; one working in vegetables, three working in fruit crops/diversification, and one devoted to banana breeding. FHIA has a biotechnology lab with PCR and tissue culture capacity. In addition, this institution has a Horticulture Research and Training Program located in the Comayagua Valley devoted to warm-climate vegetables. The foundation also operates an Agroforestry Center that works on fruit crops intercropped with forestry. FHIA also has a Banana and Plantain Breeding Program with a large research farm devoted to these crops. A Crop Diversification Program works on promoting native and exotic tropical fruit species. Even though FHIA has a Horticulture Research and Training Program, it lacks research in cool-climate vegetables since it closed a research station in the highlands of Honduras because of lack of funding. Some vegetable growers indicate that the research agenda at FHIA is not based on their needs and that the foundation has to reach out more effectively to the Honduran community in general.

4.5.2.2 GUATEMALA

Facultad de Agronomia de la Universidad de San Carlos (FAUSAC). As the main public university in Guatemala, USAC´s agriculture college has 15 faculty members with either Ph.D. or Master's degrees. The college of agriculture has a Master's program in fruit production and good laboratories for research. Additionally, this institution has education and applied research stations in Escuintla and Suchitepéquez. However, the lack of funds for doing research is the main constraint. Additionally, research performed by students is not necessarily linked to farmers' needs.

Universidad Rafael Landívar. With the main campus in Guatemala City and five regional campuses in Escuintla, Quetzaltenango, Cobán, Jutiapa, and Zacapa, this private Catholic university has a large presence in teaching agriculture in Guatemala. There are five faculty members involved in horticulture, all of whom have Ph.D. degrees. The school has good laboratories for research in the main campus, where research is conducted mostly on environmental issues. This university does some contractual research and has laboratory equipment that enables them to contract laboratory services. However, a constraint to doing research is the fact that the school´s main focus is teaching. It does not have funds for research.

Universidad del Valle de Guatemala (UVG). This university, started in the 1960s with help from the American government, has the best research infrastructure in Guatemala. UVG has five faculty members with a Ph.D. or Master´s degree working on fruit and vegetable crops. The school hosts a Center for Studies in Biotechnology with capacity for PCR and tissue culture. Additionally, its Center for Studies in Agriculture and Forestry has capacity to work on applied research on fruits and vegetables. In addition to the main Guatemala City campus, UVG has two satellite campuses with field research and teaching capabilities, in Escuintla and Sololá. The Guatemala City campus has a research program and good laboratories. The school does contractual research, as well as research in collaboration with USAID Innovation Labs (also known as CRSPs) such as the Horticulture Innovation Lab and IPM Innovation Lab. The school relies on external funds to support research and sells services to utilize their highly equipped laboratories and field stations.

Instituto de Ciencia y Tecnología Agrícola (ICTA). The research institute of Guatemala's ministry of agriculture, ICTA has 64 researchers working in various disciplines with Ph.D. degrees. The institute has 12 experiment stations distributed in five regional centers throughout Guatemala. The main campus in Barcenas, Guatemala City, has a biotechnology lab with PCR and tissue culture equipment and field space for research. As the national agricultural research institute, ICTA lacks sufficient funds for research and as a result of that, the quality of their research has declined considerably. There is no political will to increase the budget of the institute because of a long-standing union dispute with the Ministry of Agriculture. Because of the lack of funding, ICTA focuses its work on basic crops such as corn, beans, and potatoes.

4.5.3 EXTENSION CAPACITY

The need for applied research and strengthened extension programs was a primary finding of the survey of constraints to improving participation of small-scale farmers in Central America in the horticulture value chain. The success of U.S. agriculture is widely agreed to be the result of the unique land-grant university system, which fostered tertiary education in agriculture, provided funds for applied agricultural research, and established a research-based extension system.

In significant ways, this report paints a situation that mirrors that of small farmers in the United States in the second half of the 19th Century. New immigrant farmers, often from impoverished countries, found their traditional subsistence farming techniques to be unsuited to the new market-driven opportunities of the fertile lands that they were settling. Despite the ongoing civil war, the U.S. Congress recognized the need for capacity building to provide farmers with the tools to enter the new agricultural value chains, and in 1862, President Lincoln signed the Morrill Act into law. This act ceded federal lands to the states with the understanding that the land grants would be used to fund colleges focused on providing university instruction in "agriculture, military science and the mechanic arts." In 1887, the Hatch Act provided those colleges with funding to engage in research addressing major constraints to success in agriculture. Lastly, recognizing the disconnect between university researchers and farmers, the Smith-Lever Act of 1914 established the cooperative extension system, in which university employees charged with extension education and research outreach were housed in county offices. Arguably, this last innovation, never replicated in any other country (where extension is typically the function of the Ministry of Agriculture), was the key to the success of the land-grant extension system.

How might the innovative elements of the land-grant extension system be applied to improve agricultural research and extension in Central America? The region has a few universities with faculty and teaching programs addressing agriculture, but connections of their programs to the field and particularly to small-scale and women farmers are weak. There are already a number of extension professionals in the field, some of them political appointees and others funded by NGOs, but many lack adequate training and few are directly connected to universities or other research institutions. We suggest a policy initiative in which the scattered elements of a capacity building/research/extension continuum that already exist in the region are pulled together through a cooperative partnership between governments, donors, and universities. The exact configuration of such a system would obviously require thoughtful analysis, but the essentials could follow the principles of the land -grant extension model, as patterned by U.S. legislation.

The Morrill Act provided funds (through grants of federal lands) to each state to support the establishment of a college focused on instruction in agriculture and other practical disciplines. The LAC countries might be considered as 'states' within a regional land-grant extension system, and a mixture of donor, university, and government resources could be provided to ensure a focused education program in agriculture and horticulture in a select magnet university in each country. The effects of such an initiative would be to build agricultural research, teaching, and extension capacity in each participating country.

The Hatch Act funded the formation of agricultural experiment stations at the already-established land-grant colleges. In its present form, the Hatch Act funding supports the applied research of teaching faculty in the colleges of agriculture. It seems possible that a portion of the donor and government resources presently being applied to a diversity of research programs in the LAC region could be identified as a pool for support of applied agricultural research conducted by the faculty in the agricultural colleges identified or established as suggested above.

The Smith-Lever Act provided federal funds to hire an extension professional for each county in the country. These professionals are hired and administered by the agricultural colleges, but are located and supported by county administrations. The exact way in which this might be replicated in the countries of the LAC region is perhaps the most intriguing question in this proposal. What level of administration would be the appropriate location of these professionals? Is there willingness at that level to provide support (office, clerical, travel) for a university employee charged with extending research-based information to small-scale farmers in the jurisdiction and communicating research needs to relevant university faculty?

It is clear that the participation of small-scale farmers, and particularly women, in agricultural and horticultural value chains in the region depends on technical education, applied research, and national capacity building. Whatever the answers to the many questions that arise in considering this proposal, it is clear that a new approach to providing relevant and timely information is required. Developing and testing a 21st Century version of the land-grant extension model is an innovative and worthwhile approach. Once established, such a system would be the vehicle for implementing the other recommendations of this report.

5. PROPOSED SOLUTIONS AND RECOMMENDATIONS

This assessment was intended to serve as a springboard for new initiatives to address the constraints that limit the success of small-scale farmers in the horticultural industries in the Central America region.

The solutions and interventions suggested below were generated from a synthesis of interviews, surveys, and comments provided by workshop participants, published documents, and the professional experience of each of the assessment team members. The suggested interventions are grouped into regional and national approaches, and are prioritized within each section according to their level of importance. Many of the suggested solutions have been implemented somewhere in the world with differing degrees of success, likely dependent on how they were implemented. There is no silver bullet solution or one-size-fits-all approach. Instead, suggested recommendations will require further elaboration, design, and research to be adapted to local conditions.

5.1 RECOMMENDATIONS

REGIONAL APPROACHES

1. Promote initiatives to **adapt horticulture to climate volatility**. Central America is considered highly vulnerable to weather related events (drought, flooding, freezing, strong winds) which are responsible for major losses in agriculture. These events affect horticultural production, flowering/fruiting cycles and planting dates, increase vulnerability to pests and diseases and often result in severe economic losses. Climate change is expected to result in warmer temperatures in Central America. Short term and long term initiatives are required to reduce risks and vulnerability of growers of horticultural products. Some initiatives that could help are listed below:

    a. National governments should promote the establishment of irrigation infrastructure and rain harvesting technologies. Micro dams have been successfully established in Nicaragua and helped many small growers who were subject to growing crops only during the rainy season. Now, with the establishment of micro dams and drip irrigation equipment, growing has been extended well into the dry season. Availability of irrigation infrastructure should be combined with required technologies such as diesel or solar pumps for drip and low-volume irrigation systems.

    b. Develop clear guidelines to determine production areas with high risk of suffering losses due to chilling damage. This information could be useful to extend the growing season in some areas. In some regions, farmer's fields are not planted because of the risk of low temperatures.

    c. Deploy a weather forecast system that reaches small producers located in remote areas, such as in the highlands of Guatemala where farmers experience chilling and sometimes freezing temperatures during the dry months. Delivery of timely weather forecasts and severe weather warnings could be done through text messages via mobile phones.

    d. Link weather system to crop insurance systems (AMA Innovation Lab, also known as BASIS CRSP, may be of assistance).

e. Support research programs that develop, test and implement strategies and/or recommendations to adapt crops to temperature extremes.

   i. Develop critical information for temperatures/times for chilling or freezing damage and for tolerance to elevated temperatures for each crop/variety. This information will help to identify better adapted varieties and prove useful to develop insurance policies.

   ii. Prevention strategies to avoid high or low temperature impacts on crop productivity might involve active or passive approaches that should be validated under local conditions. Active methods to prevent low temperature damage might include covering the crop before chilling or freezing temperatures occur in the field. Mulching crops to cool roots, use of shade cloth and improved irrigation strategies could be tested to reduce high temperature stress.

2. Establish **regional research programs to address cross-cutting constraints** affecting the region (i.e. HLB, *Tuta* spp., *Fusarium* in musaceas, germplasm banks and variety testing). A Central American initiative led by OIRSA (Organismo Internacional Regional de Sanidad Agropecuaria) could serve as an example so that issues are addressed at the regional level. In 2012, a technical cooperation agreement between the Taiwanese Government and OIRSA was signed to tackle the devastating disease affecting citrus around the world, under the project "Fortalecimiento de la Región del OIRSA en el control del Huanglongbing (HLB) y la implementación del manejo integrado de plagas en cítricos." As part of this agreement, a centrally located germplasm bank would be established to distribute healthy seedlings and bud wood for all countries in the region (except Mexico and Costa Rica). In addition, greenhouses will be built and technical training will be provided to produce grafted material. Additionally, laboratories to grow the parasitoid *Tamarixia* will be established as part of an IPM effort. Demonstration plots were being planned in 2013 when a group from Taiwan visited Central America. Concrete examples of crop-specific needs are presented in Appendix F. Regional activities to support efforts to tackle pests and diseases affecting horticulture crops will benefit from:

   a. A regional IPM program to address major pests, diseases and weeds. Within this program, efforts could be directed towards research and innovation to develop and promote the adoption of non-chemical control methods (i.e. antagonistic fungi, entomopathogenic fungi and bacteria and endophytes, among other approaches). Such an effort will reduce the current trend of pesticide overuse, which results in chemical residues and export rejections. In addition, such technologies could contribute to adherence to new regulations under the new Food Safety Modernization Act. Some of this work could be conducted in collaboration with the IPM Innovation Lab.

   b. Establishment of a regional platform with key players in Guatemala, Honduras and the other country's institutions in the region, to do research with a regional focus or mandate.

      It would be best if such an effort was led by a regional institution. Possible candidates include the CATIE, the Inter-American Institute for Cooperation in Agriculture (IICA), or an international institution from the CGIAR such as Bioversity International or the International Potato Center (CIP). Other CGIAR centers that could contribute to research topics directly relevant to the constraints affecting the horticulture sector are: CIAT (i.e.

climate change adaptation and mitigation, market related research, diversification of agroforestry systems), and ICRAF (agroforestry work). Either of these entities could lead a regional project to manage cooperative research partnering with national organizations.

Another approach to capacity building for these research institutes and universities is to support a partnership with a complementary U.S. university to engage in work on curriculum development and improvement, faculty training, and targeted and effective collaborative research projects. Such an effort can be supported through the Feed the Future Innovation Labs (particularly Horticulture, AMA and IPM) model.

c. Training in diagnostics and management of pests and diseases. One such initiative is The Plant Clinic (http://www.plantwise.org), a CABI led initiative, which already operates in Honduras and Nicaragua and which has established 300 plant clinics in 24 countries around the world. The Horticulture Innovation Lab has also trained numerous individuals in Latin America in *Phytophthora* diagnostics, and created a network of such expects to share information across the region. The enhancement of databases with information about the distribution, diagnosis and control of pests and diseases affecting regional crops will help to control pest problems in Central America.

d. Agricultural technology development and transfer that is led by a regional organization that can be stable over time even with changes in national agricultural organizations. The goals of the Horticulture Innovation Lab's Regional Center at Zamorano match well with this concept. Other regional organizations could also be involved.

e. Identification of alternative crops for small scale coffee growers who may no longer able to profitably grow coffee due to the coffee rust (la roya) crisis.

   Coffee farmers affected by the coffee rust crisis and increased global production of robusta coffee may be in need of alternative, high value crops. Horticulture crops provide a good opportunity. IICA conducted a study in 2010 to determine the most promising fruit crops for Guatemala. A similar study should be conducted for vegetables in Guatemala and for fruits and vegetables in Honduras and other places in the region, as appropriate to identify the most promising, high-value crops for these growers.

f. Develop and support a research agenda focusing on sustainable production systems in the region. Production systems could be evaluated for social, economic and environmental sustainability, and should include modern technologies whenever possible. FHIA, CATIE and IICA, as well as other CGIAR centers (CIAT and ICRAF) focusing on a systems approach for agriculture are active in the region and have accumulated considerable experience in the subject.

   i. Evaluate, demonstrate and support research on agroforestry alternatives to be utilized as part of a strategy to increase resilience, diversify agriculture, minimize risks against climate change, enhance biodiversity conservation, and environmental services (i.e. Quesungual agroforestry system).

   ii. Promote research to evaluate mixed cropping systems.

   iii. Facilitate access to technologies suitable to promote adoption of green manures and composting technologies.

3. Promote regional and national **training and education programs on appropriate technologies to reduce postharvest losses** and comply with the Food Safety Modernization Act (FSMA) throughout the horticultural value chain.

   Postharvest mishandling accounts for more than 30 percent of productivity losses in many horticultural crops. Lack of knowledge and appropriate technologies are the biggest constraints. Implementation of the FSMA increases the importance of using appropriate handling practices in the field and after harvest. The following approaches are recommended to address this need:

   a. Strengthen postharvest and food safety capacity and training at universities in the region.

   b. Conduct trainings on best practices for producing and marketing safe, high quality produce, including attention to the principal routes of microbial contamination (agricultural water; biological soil amendments of animal origin; worker health and hygiene; equipment, tools, buildings and sanitation; and domesticated and wild animals).

   c. Highlight economic incentives to eliminate barriers for the adoption of postharvest technologies and methods.

   d. Reduce tariffs on import of postharvest equipment and supplies or develop local manufacturing facilities.

   e. Promote development and utilization of appropriate infrastructure.

      i. Simple shaded packing sheds

      ii. Small-scale coolers near growing locations

      iii. Standardized rigid plastic containers for produce

      iv. Insulated or refrigerated transportation units

4. Promote regional initiatives to conserve, characterize and facilitate access to diverse and **improved germplasm of horticultural species** (commercial crops as well as native fruits, vegetables, and ornamentals). Such programs could involve national agricultural research systems (NARS) as official repository of genetic resources in many countries, local and international universities and a regional organization as regional coordinator. Given the rate of expansion of commercial horticulture, deforestation, and environmental degradation of the Central American region, native genetic resources are at risk of being lost. With a goal to diversify horticultural production, increase resilience and food security, and develop new products, a series of alternatives could be considered:

   a. Support national strategies and events that promote conservation, and exchange of genetic resources between communities, such as **seed fairs**.

   b. Develop strategies to support **germplasm banks** at the regional level, to facilitate evaluation and characterization (i.e. resistance or tolerance to biotic and abiotic stresses, nutritional quality, and consumer acceptance), exchange and distribution of genetic material across countries in the region.

   c. Evaluate and promote strategies for local seed production schemes that are sustainable and provide year-round production (Horticulture Innovation Lab is currently training women's groups in Honduras and Guatemala to produce and market seed of improved vegetables).

d. Develop branding for indigenous crops. Promote innovative strategies to add value to indigenous crops, aiming to develop branding to position unique products from the region. More about the development case for adding value through branding can be found at www.iied.org/pubs. Branding will increase revenues for growers, if properly implemented.

NATIONAL APPROACHES

1. Reduce the economic risks to horticultural farmers though availability of **effective crop insurance** programs.

    a. Design a sustainable crop insurance system or risk management tool on a regional scale, suitable but not exclusively for small scale farmer's groups (i.e. cooperatives or even a given region with a high concentration of small farmers) to provide a safety-net for farmers. When weather-related events occur, they tend to affect several countries simultaneously, therefore concurrently affecting millions of farmers in Central America. Such crop insurance could be a public-private partnership, including the insurance companies, governments and farmers. Such systems have been recognized as the most sustainable and effective crop insurance programs for developing countries (Herbold 2011).

2. Design and test an **interlinked microcredit-index insurance** product. A promising approach to the lack of both credit and crop insurance is the interlinkage of microcredit with novel forms of agricultural index insurance that protects lenders—and borrowers—against the risk of simultaneous default, as proposed by the AMA Innovation Lab. In contrast to conventional agricultural insurance, which has proven to be infeasible for small-scale farmers, index insurance makes indemnity payments based on the performance of an easily measured and verifiable index (e.g., weather conditions) that is correlated with average farmer outcomes. While index insurance and credit interlinkage is a work in progress, a number of microlenders worldwide are keen to harness it as an instrument that will allow them to offer credit at reasonable interest rates to still underserved small farm credit markets. Horticultural crops present a unique set of challenges to the design of interlinked credit-index insurance contracts, but given the potential of these crops to boost small farm incomes, it is clearly time to invest in instruments that promise to relax the key economic constraints that hold back this sector.

3. **Improve national extension systems** to ensure research information, best practices and technologies are delivered to smallholder farmers. A number of models could be tested, including the land-grant extension model utilized in the United States under the Smith-Lever Act. We suggest a policy initiative in which the scattered elements of a capacity building/research/extension continuum that already exist in the region are pulled together through a cooperative partnership between governments, donors, and universities. The exact configuration of such a system would obviously require thoughtful analysis, but the essentials could follow the principles of the land-grant model, as patterned in U.S. legislation.

    A pilot system could be tested initially in Feed the Future provinces of Honduras and Guatemala. Such systems could benefit from policies that:

    a. Maintain a horizontal approach and the independence of the members.

    b. Provide a significant government role, but without political interference.

c. Promote/facilitate a prominent role(s) for women, including leadership roles.

d. Facilitate collaboration/cooperation among members to eliminate redundancies.

e. Promote sustainability of the system. For example, provide incentives for the participation of the private sector through a tax break if technical assistants are fully trained using private sector resources.

f. Provide incentives for collaboration/cooperation among different projects and organizations, linkages between universities and other institutions such as NGOs and industry (Link extensionists with research professionals in universities and other research institutes).

g. Provide access to technology and new technology delivery means (i.e. use cell phones as the primary platform) to a broader range of farmers, especially small ones. Such systems could consider these characteristics:

    i. Local language

    ii. Text-free systems (agricultural TV channel, YouTube, tablets)

    iii. Visual media, especially video: The proliferation of inexpensive tablets, smart phones or digital recording devices would facilitate the production of professionally produced farmer-to-farmer videos using language familiar to the target farmer audience. Best practices could be recorded to be shared among farmer's groups during, for instance, farmer movie nights. It has been shown that web-based videos do not reach individual farmers as easily as other agencies (NGOs, universities, research organizations) that are better connected to the web (Agro-Insight 2011).

h. Foster training in participatory research/technology for testing production innovations and adoption methodologies, such as Local Research Committees (Comités de Investigación Agrícola Locales http://webpc.ciat.cgiar.org/metodologias_ca/investigacion/cials.html). This methodology has been found suitable for work in communities where technical assistance is almost non-existent or not likely to exist.

4. Develop trusts or other microfinance means for **financing smallholder farmers**, particularly women and indigenous peoples. Financing is restricted and less accessible to smallholders, which limits the investment by small growers in inputs to enhance their crops (fertilization, crop protection inputs, packaging, shipping). For example:

    a. Microfinance has been successful in Asia as a vehicle to increase women's access to financial capital. Moreover, in Central America, many women's groups implement a savings model called the tanda, a scheme that enables them to save money for expensive purchases. Efforts like these could be formalized to support small farmers. This type of intervention could be researched by economists (AMA Innovation Lab, various NGOs) and implemented by governments or the private banking sector.

    b. The development of a policy for agricultural financing which facilitates the use of trusts by producers, and is designed and adapted to the horticultural sector, including rules that the banking institutions remain committed to mainly use low-interest funds for horticultural producers. An example is found in Honduras for the citrus industry. Producers deliver fruit to a processing plant that keeps a small percentage of the price to feed a trust fund that is used to train farmers and technical personnel from both the private and public sector in disease control, particularly about the much-feared Huanglongbing disease that threatens the citrus industry in the region. The trust fund also pays for pest control efforts. The government has one member on the board that oversees the fund, which is managed by a private bank, and the government also contributes to the trust fund.

5. Develop national policies to support **well-funded, long-term national agricultural research systems** (NARS), including training of graduate students (i.e. Sistema Nacional de Investigación y Transferencia de Tecnología Agropecuaria, SNITTA in Honduras). The national systems should not only include the NARS, but should include a broader array of research and technology transfer organizations focused on supporting the development of the horticulture industries at the national and regional levels. The National Agricultural Research Systems could have the following characteristics:

    a. **Funding could derive from public-private partnerships.** A funding scheme might include tax incentives to the private sector so that it invests in research to generate public goods. Such policies exist in other countries, and become an additional source of funding to promote research and innovation. Successful programs have been implemented in many countries. For example, a program in Colombia that is managed by Colciencias (equivalent to the U.S. National Science Foundation, but much smaller) accepts proposals for funding from the private sector together with research organizations (universities, NARS, private research centers, etc). In this case, if the private sector contributes $100, then the government provides a tax deduction based on $125. Therefore, the capital funds they provide are tax free plus 25 percent, which is a win-win for everyone.

       Also in Colombia there are specialized research centers, called CENIs. Each center is dedicated to a particular industry and is supported by an industry levy of ~2.5 percent of revenue. For instance, Cenipalma focuses on research on palm oil and is supported by that industry. The industry is able to direct the research program.

       Another fiscal fund for fruits and vegetables is administered by the Asociación Hortifrutícola de Colombia. For every commercial transaction where an invoice is generated, 1 percent of that value is collected as a tax. The resources are used to support research, marketing, and technical assistance.

       In Australia, a levy system is used to raise an equivalent fund by the government. For every dollar provided by the private sector for research, the government uses the fund to allocate another dollar (1:1 match). The industry decides on the type of research that is supported by the fund.

       The suggestion of tax breaks or tax incentives have not been validated with fiscal policy makers in Honduras or Guatemala, and therefore the feasibility of this approach in these countries remains to be determined.

    b. **Develop a national horticulture research and innovation plan**. Such plan should derive from a broad and inclusive consultation with different actors and sectors. It could be created by promoting linkages between research/higher education institutions with farmer groups/federations, service and input providers and other value chain actors to provide needed focus on solving critical issues affecting horticulture and agriculturally related activities (water quality, environment, biodiversity, technologies, finances, etc.).

c. **Develop partnerships between U.S. and Central American region institutions** to work on research activities in support of regional needs under the auspices of the Horticulture Innovation Lab. Such an activity will serve to build the capacity of local institutions to do research and outreach while addressing key needs of the region. These collaborative research activities could be designed to address many of the recommendations in this report, with funding from the Bureau for Latin America and the Caribbean or country missions. Two specific examples are given below:

    i. In partnership, assess the potential of alternative crops for small-scale coffee growers.

    ii. The Horticulture Innovation Lab, in partnership with Central American institutions, can assist in implementing the action plans previously developed by PROMEFRUT for the LAC region, particularly in the area of knowledge generation— developing online resources of information about plant health, quality platforms, germplasm and safety.

6. Develop mechanisms to **coordinate and enhance the marketing of horticultural products** from smallholder growers. Smallholders sell their produce through different venues, including direct sales in local markets, selling to intermediaries, or contract sales through formal markets (wholesale or supermarkets). A Participatory Market Chain Analysis (PMCA) could be used to gain cooperation and participation of various sectors of the horticultural industry. Such a program might include the following characteristics:

    a. Work with supermarket chains domestically to connect smallholders to formal markets with contracts and transparent systems.

    b. Support PMCA of various supply chains in regions rich with smallholder farmers to encourage communication and relationship building with traders and buyers through establishment of business centers. Foster agribusiness linkages among such groups by training farmers in business skills. NGOs could play a role in providing agribusiness training.

    c. Promote local government initiatives to enhance conditions in local markets (i.e. seed fairs, wet markets) so they become attractive to a broader range of customers and also so that small farmers can sell their produce locally.

    d. Promote producer associations who can market cooperatively with more power and assist them to develop successful and sustainable business models for all of their members.

    e. Provide information about demand and prices through radio, TV programs and cell phones where daily prices of fruits and vegetables are reported for major markets.

    f. Deliver training about quality and safety requirements, and postharvest handling to farmers, transporters and buyers (especially related to FSMA).

    g. Support initiatives for planned planting, consistency in delivering of volume and quality for smallholders as well as close coordination with local, national and regional buyers.

    h. Develop incentives that influence private policies to ensure fair access for small growers.

i. Influence private policies for prompt payment and support sustainable business development (i.e. fair trade approaches for local markets).

j. Implement national programs for promoting agribusiness linkages between growers and buyers that favor formal agreements for buyers to purchase horticultural products, and for producers to access horticultural supplies. An exemplary case is Multiverdur, a farmers company in Guinope, El Paraíso, Honduras. A buyer provided collateral for a US $250,000 bank loan, which was used by the farmers to purchase horticultural supplies in bulk to produce onions at lower cost and, ultimately, the onion harvest was used to repay the loan.

7. Create incentives (e.g. tax breaks) and enabling environment to **develop horticulture-oriented business services**, especially those that are suitable for smallholders. Some of those services could include:

    a. **Protected cultivation technologies** (row covers, tunnels and houses). Adoption of these technologies can be seen in the field already, as they are viable options to reduce losses from adverse weather events as well as from major pests and diseases, and are technologies adaptable to small scale growers.

    b. Facilitate the establishment of commercial laboratories, be it national or regional ones, to test fruits and vegetables for chemical residues and human pathogens. Some commercial laboratories offer analyses of up to 250 active ingredients per sample. Although analyses are still costly and therefore not affordable to individual growers, they might be more cost-effective than testing for individual molecules in traditional less equipped testing facilities. Cooperatives engaged in export markets could be in a better position to negotiate deals with commercial laboratories.

    c. Modern irrigation, packaging, small-scale cold rooms, and small scale processing technologies.

8. Develop policies to **facilitate the participation of indigenous peoples, smallholders and women in value chains**. Such policies could be developed independently or jointly between the public and the private sector.

    a. Support policies that provide access to land and resources that minorities are often denied. Reduce barriers and the financial cost of these transactions to facilitate the participation of disenfranchised groups.

    b. Empower women to participate within the horticulture value chain in more dynamic ways. Ownership of land and small businesses provide women with the financial independence needed to make decisions and take control over their own resources and future.

        i. Agribusiness training, focusing on the steps needed to enter new markets.

        ii. Train women to process and sell horticultural products to increase the end value of their production.

        iii. Farmer field schools directed towards women.

        iv. Female extension workers are more able to connect to female farmers, especially in rural areas.

c. Establish mentorships for young women and indigenous peoples, who are regularly less empowered.

d. Find a way to increase women's participation in cooperatives and their own organizations by involving both sexes in meaningful training that empowers women to make decisions while improving the livelihoods of men.

e. Develop specialized training materials and delivery means (ICTs) to speed skills development and improve understanding of quality standards and adoption of production technology.

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APPENDICES

APPENDIX A: LIST OF PEOPLE INTERVIEWED AND THEIR CORRESPONDING ORGANIZATION, BY COUNTRY

List of people interviewed in Honduras

Segment	Organization	Position
DP	EmprendeSur	Director
DP	FINTRAC	Director
DP	FINTRAC	Sub Director
DP	FINTRAC	Mercados
DP	FINTRAC ACCESO	Gerente Depto Intibucá
DP	FINTRAC ACCESO	Asesor Politicas, ex ministro SAG
DP	Pronegocios Rurales	Director
DP	COMRURAL	Director
ET	Zamorano- Escuela Agrícola Panamericana	Director Agronegocios
ET	Zamorano- Escuela Agrícola Panamericana	Profesor Hortalizas
ET	Zamorano- Escuela Agrícola Panamericana	Profesor Frutales
F	Banco BANADESA	ex presidente
G	ex Ministro de Agricultura	
G	Ministro Agricultura	
G	Secretaría Industria y Comercio SIC	Jefe Negociación Comercial
G	Secretario FEHPROH	
G	SENASA	
IC	IICA-Agronegocios	
IC	Representante FAO Honduras	
IC	USAID	Agricultural Recovery Advisor
IC	USAID	Senior Agriculture Advisor
IC	USAID Honduras	Sub Director Desarrollo Econ
IC	USAID Honduras	Oficial Programa
IC	USAID Honduras	Asist Programa
IC	USDA APHIS Honduras	Técnico
IC	USDA FAS Honduras	Mercados
M	Central Abastos Sula	Comercializador
M	Central Abastos Sula	Comercializador
M	Corp Dinant	Gerent Planta Alimentos

M	Corp Dinant	Gerente Empaque
M	Corp Dinant	Gerente Cultivos Protegds
M	INALMA procesador	Gerente Operaciones
M	Hortifruti Walmart Honduras	Gerente Compras
NGO	OCDIH Organismo Cristiano p el Des Integral	Monitoreo y Eval
NGO	ODECO Organización p el Des d Corquín	Coord Incid Política
P	Agricola ANTAR	Gerente Propietaria
P	Agricola ANTAR	Gerente Tecnico
P	APRHOFI	
P	ASOFAIL (Asociación de Familias Agricolas de Intibucá Ltda)	
P	Coop Productrs Mango COPETROL	Directivo
P	FENAPA (Federación de Productores Papa)	Presidente Directiva
P	FPX Federación de Productores y Exportadores de Honduras	Gerente General
P	FRUTELA	Directivo
P	FRUTELA	Directivo
P	FRUTELA	Gerente
P	FEHPROH	Presidente
P	Proyecto Horizontes Norte	
P	Red Hortícola de Intibucá	
R	FHIA	Director General
R	FHIA	Director Investigacion
R	FHIA Comayagua	
SP		
SP	FUNDER-Fundación	Jefe Centro Agronegocios
SP		
SP	CENOC (Centro Empresarial y de Negocios de Ocotepeque)	Miembro
SP	Empresa Asociativa Campesina Chululan	
SP	Fundación Jicatuyo	Gerente Finanzas
SP	Fundación Jicatuyo	Gerente Gestión Empresarial
SP	Fundación Jicatuyo	Gerente General
SP	Fundación Jicatuyo	Directivo
SP	Fundación Jicatuyo	Presidente Directiva

List of people interviewed in Guatemala

Segment	Organization	Position
ET	Universidad Rafael Landívar	Decano Facultad de Ciencias Ambientales y Agrícolas
ET	Universidad del Valle de Guatemala	Director Centro de Estudios Agricolas y Forestales
ET	Universidad del Valle de Guatemala	
ET	Universidad del Valle de Guatemala	Decano, Facultad de Ingenieria
ET	Universidad del Valle de Guatemala	Directora, Ingenieria en Ciencias de Alimentas
G	MAGA-CONADEA (Consejo Nacional de Desarrollo Agropecuario)	Secretario Ejecutivo
G	Gobierno de Guatemala, Ministerio de Agricultura, Ganaderia y Alimentacion	Jefe de Oficina Normas y Procedimientos
G	MAGA-CONADEA (Consejo Nacional de Desarrollo Agropecuario)	Asesor
G	CONPRODAN	Secretaria de Cadenas
G	MAGA-CONADEA (Consejo Nacional de Desarrollo Agropecuario)	Director CONPRODAN
G	PROFRUTA/DEFRUTA	
G	DEFRUTA MAGA	Director
IC	IICA	Coordinador Innovacion para Competitividad y Productividad
IC	IICA	Representante IICA en Guatemala
IC	IICA	Division Hortalizas y Frutas
IC	FAO	Oficial de Alianzas
IC	USDA	Especialista Internacional
IC	USDA	Coordinador Programa Internacional
IC	USDA	Consejero Agricola
IC	USDA	Especialista Fitosanitario
IC	USDA	Especialista Agricola
IC	USAID USDA?	Coordinador Regional MSF y SIM
IC	USAID	Consejero Agricola
IC	USAID/GUATEMALA	Subdirectora Oficina Desarrollo Economico
IC	FAO-PESA	Tecnico Nacional
IC	FAO-PESA	Tecnico Nacional

IC	FAO	Experto Comercializacion
IC	FAO	Coordinador AUP
IC	FAO	Agrocadena Papa
DP	ANACAFE	Director del Proyecto
DP	ANACAFE	Experto en Desarrollo Rural
DP	ANACAFE	Monitoreo y Evaluación
M	Asociacion Guatemala de Exportadores (AGEXPORT)	Director Division Agricola y Pesca
NGO	Save the Children	Especialista Agronegocios
NGO	CARE Guatemala	Directora Nacional de Programas
P	Productor Independiente	
P	FASAGUA	
P	FRUTASA (Fruticultores Asociados del Altiplano)	Administrador
P	Assoc. Prodesarrollo de la Familia Ixil	Presidente y Representante Legal
P		
P	Finca San Juan Bautista	Dueno
P	MAM, Retalhuleu	Representante de Comunidad
P	Assoc. de Fruteros, Genoa	
P	Assoc. de Fruteros, Genoa	
P	Comunidad La Reina	Presidente
P	Comunidad La Reina	Vigilancia
R	ICTA	Subgerente General
R	ICTA	Bioquimica y Biotecnologa Laboratoria de Biotecnologia
R	ICTA	
R	UCDavis	Especialista Post Cosecha
R	ICTA Quezaltenango	Administradora
R	ICTA Chemaltenango	
R	ICTA Chemaltenango	Especialista Agroindustria
R	ICTA Chemaltenango	Especialista Agroindustria
R	ICTA Chemaltenango	
SP	Vista Volcanes S.A.	Ex Gerente General
SP	Vista Volcanes S.A.	Director
SP	Vista Volcanes S.A.	Gerente Administrativo
SP	Agroexpertos	Director General
SP	OIRSA	Representante
SP	OIRSA	Fitosanitario
SP	Fundacion Juan Francisco García	

SP	Cooperacion Agricola Integral (Los Cuatro Pinos)	Proyectos Productivos
SP	Cooperacion Agricola Integral (Los Cuatro Pinos)	Coordinador Logistica de Contenedores
SP	Grupo DUWEST	Aseso Tecnico de Ventas
SP-M	Frito Lay Central America	Asesor Programa Agricola

List of people interviewed in El Salvador

Segment	Organization	Position
G	PROMEFRUT	Directora Proyecto PROMEFRUT
ET		Profesor fruticultura
G		Coord Programa Invest Frutales
IC	FOMILENIO	ex Dir Proyecto FOMILENIO (Cuenta Desafío Milenio)
IC		Directora Econ Growth
IC		Econ Growth
IC		Value Chain Centro América
IC		Coordinador Programa Agric Familiar

ET = Education and Training (Local and International Universities)
G = Government
IC = International Cooperation (international support agencies)
DP = Development Project
M = Markets (informal, formal, processors)
NGO = Non-government organization
P = Producer, Producer organization
R = Research
SP = Service providers (finances, technologies, analysis)

APPENDIX B: LIST OF ALL ISSUES MENTIONED DURING THE IN-PERSON INTERVIEWS AND CONSULTATION WORKSHOPS

List of all aspects considered as limiting factors, mentioned during the interviews and workshops.

ECONOMIC

LACK OF ADEQUATE FINANCIAL SUPPORT FOR HORTICULTURE AND LACK OF CAPITAL FOR SMALL PRODUCERS

- Annual interest rates on loans for horticulture can be as high as 36%.
- The banking sector does not promote low interest loans, only those with the bank´s own funds and at high interest rates.
- Loan approval is a slow and cumbersome process, generally requiring the loan be mortgage-secured.
- Financial products—with grace periods taking into account growing cycles—are not commonly available for horticulture cropping.
- Development projects do not include funds for working capital.
- The banking sector provides financing services mainly to large producers.
- Low-interest, public financing for agriculture is used for other ends; political influence is required to access credit.
- Small producers do not have access to foreign funds because of the type of crops they produce (beans, sorghum, maize, rice, potatoes). (Guatemala)
- Access to credit is difficult for women horticulture producers. The women´s cooperative "*Cooperativa de Mujeres 4 Pinos*" was created to address this issue. (Guatemala)
- Banks establish excessive requirements for approving a loan (demanding guarantees worth five times the value of the loan). (Guatemala)
- Producers do not own the appropriate vehicles or resources to transport their produce. (Guatemala)
- Small producers do not have the resources to purchase inputs, equipment, infrastructure, etc. Fertilizers are purchased only when the harvest is sold.

LACK OF TRANSPARENCY IN BUYER-SUPPLIER RELATIONSHIPS

- Buyers make loans to producers at 30% interest rates, and apply product rejection policies of as much as 50% when there is surplus.
- Sometimes exporters do not pay farmers, but keep the produce.
- Breach of contract is common, producers are paid on an irregular schedule, and price volatility is high.
- During periods of surplus, farmers sell their produce for less than production costs.

DEPENDENCY CULTURE GENERATED BY DEVELOPMENT PROJECTS

- Farmers rely on projects or institutions for marketing and transporting their produce, thus generating dependency on these institutions or development projects.
- External aid serves the same areas and same farmer leaders. Scope of coverage needs to be broadened.

AFFORDABLE AGRICULTURAL CROP INSURANCE UNAVAILABLE

- Small producers do not have easy access to affordable agricultural crop insurance.

MARKET ISSUES

- There is little negotiating power by small farmers and a high degree of distortion of markets by both wholesalers and growers due to speculation on both parts.
- Imported seeds (onions and potatoes) come from countries with high subsidies, and contraband from neighboring countries affect local producers.
- Farmers have limited access to new markets and there is little help from the Ministry of Commerce to address this and other trade issues.
- The local market is underdeveloped with no true farmers' markets, which are instead run by business people from the informal wholesale markets in many cases.
- There is a generalized lack of prompt payment or a practice of late payment to growers and no willingness by buyers to sign contracts.
- Overall, producers lack information on markets.
- Access to formal markets, such as supermarkets, is difficult for small farmers, and they do not have direct contact with traders in wholesale markets.
- Small farmers relate mainly with intermediaries.
- Mechanisms are not in place for producers to sell directly to consumers, or in local or national markets.
- Contraband from neighboring countries is an important limiting factor since producers cannot compete in prices with illegal imports.
- Processing plants are required in order to maintain good prices. There is a growing tendency to process vegetables in other countries.
- There is not enough surplus for processing (as is the case with papaya).

LACK OF PROTECTION AGAINST FREE-TRADE AGREEMENTS

- Small/poor countries are at a disadvantage in free-trade agreements (FTAs)
- Inequitable marketing relationships among countries signing the FTAs.

HIGH COST OF PRODUCTION (SUPPLIES, SEEDS, EQUIPMENT/EQUIPMENT IMPORT TARIFFS, ETC.)

- Agricultural inputs (seeds, pesticides, etc.) are expensive in comparison to their costs in other countries in the region, reducing competitiveness of national production.
- Duties on imported processing equipment are high.

- Locally produced raw materials for processing are expensive (plantains, tomatoes for paste, etc.).
- Processes for complying with international sanitary export requirements are expensive and will be even greater when new standards are enforced (U.S. Food Safety Modernization Act).
- Competitiveness of horticultural cropping is low.
- Horticultural production costs are high due to the high cost of labor involved.
- Some horticultural products are no longer profitable to produce because of the high cost of production or overproduction.
- Organic products are not well known, nor are buyers ready to pay a higher price than for conventional produce, acting as a negative incentive for organic farming.
- Productivity of horticultural cropping is low.
- Low salaries in horticultural farming discourage labor supply.

LACK OF INCENTIVES FOR PRODUCTION

- There is a marked absence of programs for promoting organized vegetable and fruit production.
- Initiatives are missing for staggering production and reducing seasonality, resulting in producers taking their harvests to the market all at the same time.
- Lack of serious consideration of native and other potentially profitable crops.

CROP MANAGEMENT

PLANTING CHOICES

- Production is not diversified, concentrating mainly on growing staple crops, especially subsistence crops in low productivity maize and bean production systems.
- Product supply in the market is not diversified. Farmers are reluctant to innovate, for example to grow colored potatoes or potato varieties fit for processing.
- Production of traditional species (such as blackberries, saisoco *[Asplundia utilis]*, asparagus, pacaya *[Chamaedorea costaricana]*, chichicuilote, capuca, caña de palmera *[Sabal umbraculifera]*, loroco *[Fernaldia pandurata],* pendant amaranth, giant yucca, pito *[Olyra latifolia]*, etc.) is not being exploited.
- Specialized planning—with a territorial approach taking into account the different agroecological zones—has not been implemented.
- Even though agroclimatic conditions in Honduras are optimum for banana production and demand is high, area planted to this crop has reduced considerably in the country. An opportunity for alternative crops?
- Large producers are reluctant to experiment with vegetable and fruit production—which remain as opportunities for small farmers.
- Suppliers of inputs sell seed of varieties that are not adapted to local agroclimatic conditions.

PLANNING

- Since cropping activities are not well planned, harvested crops sometimes reach the market when prices have dropped.
- Lack of planning and scheduling of cropping activities result in deficiencies in supply of produce to the market.
- Distortion in production is the result of traders distributing seed arbitrarily to promote production and stock up on produce.
- Due to lack of crop planning and organization, when market prices increase for a specific product and year, area planted to this crop increases the following year, resulting in supply exceeding demand and prices dropping.
- Concentration of demand reduces the bargaining power of farmers.
- Export opportunities are wasted due to lack of production organization. (A mango processing plant operates in Comayagua, Honduras, but producers only exported during 2 years.)
- Honduran farmers have not taken action to control neighboring country vegetables from flooding the market.
- Products do not have a certificate of origin ("Honduras" branding) to promote sales of national production.
- Farmers do not have control over their harvests after delivering produce to traders.

ENGINEERING/TECHNOLOGY

AVAILABILITY OF WATER AND IRRIGATION INFRASTRUCTURE

- Overall lack of irrigation infrastructure and equipment.
- Low investment level in irrigation infrastructure.
- Current irrigation systems and methods are often inefficient.
- Availability of irrigation districts and equipment is not sufficient and farmers, especially women, spend hours carrying water for home consumption and irrigation.
- The higher altitude zones experience a deficit in vegetable production during the period between November and March due to frosts and lack of water.

POSTHARVEST

- Lack of adequate packing and transportation means.
- Actions are missing to promote value-added products, and very few enterprises are dedicated to processing agricultural products.
- Donor funds, often redundant, are invested in vegetable and fruit wholesale/distribution centers which later become "white elephants."
- Lack of vegetable postharvest equipment, such as portable washing equipment that can be easily transported in a pick-up truck.

- Training is required on handling perishable products in order to maintain their quality and prolong their shelf life.

PROCESSING

- Lack of fruit and vegetable processing infrastructure.
- Little processing of second-rate quality fruits and vegetables.
- Lack of advanced/simple training on fruit and vegetable processing.
- Fruit and vegetable processing facilities are isolated in academic, professional training and government institutions.

PRODUCTION TECHNOLOGY AND SUPPLIES

- Lack of technology for protected agriculture.
- International organisms do not prioritize certain horticultural products (e.g., Harvest Plus does not include bananas and plantains in its priorities).
- Training and technologies—in the form of specific and necessary products/services, such as stakes, strings, meshes, plastics, substrates—are not available for vegetable cropping.
- Small farmers do not have diagnostic services to detect chemical or biological residues.
- Even though Guatemala´s institute of agricultural technology (*Instituto de Ciencias y Tecnología Agricolas*, ICTA) has a processing research program, they have not been able to develop many processed commercial products due to lack of resources and knowledge on agro-enterprise development issues.

INFRASTRUCTURE

- Roads are in very poor condition, a major infrastructure issue.
- Secondary road infrastructure in poor conditions, hampering transportation of produce to markets.
- Difficulties in transporting produce due to poor conditions of roads. (For example, 13 hours are spent traveling over the stretch of road between Choluteca and San Pedro Sula due to mounds of dirt and potholes.)

EDUCATION AND TRAINING

LACK OF CAPACITY OF GROWERS AND PERSONNEL OFFERING TECHNICAL ASSISTANCE

- The lack of operational capacity among growers results in low-quality produce, low productivity, inadequate production practices, and incomplete production costs analyses.
- Technical assistance offered by some local NGOs and representatives of agrichemical companies is not a guarantee of updated information, new approaches to solve old issues, old approaches to solve new issues, and free of conflict of interest when selling a product.
- Technical service providers are not certified, and there is no regulatory system in place to oversee its functions.
- Rural schools do not offer education related to agriculture.

- Farmers have limited financial analysis capacity to establish production costs.
- Some practices like re-packaging agrochemicals allow inferior/ineffective or fake products to be sold to growers.
- Limited training of rural nutrition promoters aiming to enhance diets in rural communities result in limited impact.
- Although natural resources could be available (i.e. water) limited operational capacity such as irrigation infrastructure limits their production potential.

LIMITED RESEARCH CAPACITY, ACCESS TO RESEARCH AND INCENTIVES TO ENROLL IN AGRICULTURE-RELATED CAREERS

- Research capacity at the country level is very limited, although several universities and organizations are present in Honduras and Guatemala.
- Funding and time allocated to conduct research is limited, if available.
- There is a disconnect between research projects and agriculture issues, and a lack of focus on real needs.
- DICTA is focused on food security based on basic grains, and horticulture crops are neglected.
- Occasionally, laboratories are well equipped but do not have qualified personnel to operate equipment/instruments.
- Laboratories to diagnose pests, diseases and chemical residues do not exist and are critically needed.
- Research on native species (issues, domestication, cultivation practices, and genetic resources) is limited.
- Agriculture is no longer attractive to new generations, and universities are focusing more on training students in business development rather than forming new researchers or extension agents.
- Fruits with export potential do not have export protocols and risk analyses.
- Postharvest technologies and innovations are limited.

LACK OF REGULAR/STABLE EXTENSION SERVICES

- Producers are aware of restrictions, yet take the risk of applying chemical products right before harvesting.
- Technical assistance as a primary government strategy is lacking: it is in the hands of development projects (NGOs) and private companies.
- Large producers and some producer cooperatives offer limited technical assistance to producers.
- Chemical sales representatives are not always well trained nor well informed, and offer biased technical assistance to make a sale.
- Technical assistance offered by several NGOs is of low quality, limited coverage and not always coordinated.

- Multiple, often redundant, sources of technical assistance, without coordination or integration = “silos.”
- Small farmers use mixtures of agrochemical products, risking surpassing the maximum residue limit (MRL).
- Technical assistance to famers involved in development projects ceases when project funds are no longer available (e.g., Danida´s agronomists).
- Technical assistance to famers involved in government projects lasts as long as the government of the day is in office.
- Implementing of preventive agrochemical residue analyses is uncommon.
- Guatemala´s agricultural and environmental protection program (*Programa Integral de Protección Agrícola y Ambiental,* PIPAA) is located in AGEXPORT (the Guatemalan association of exporters) and mainly provides support to exporters, offering no protection to farmers that do not export.
- ICTA provides agricultural technology extension and transfer services, following the learning-by-doing approach in the classroom and in the field; however these programs are ineffective due to their low operating budget.
- Frequency of technical assistance provided by producers’ associations (cooperatives) is very low (1 technician for 200 plots).

LACK OF DIALOGUE AND COORDINATION AMONG DEVELOPMENT PROJECTS IN THE REGION

- Several projects/agencies are tackling similar regions/problems, but do not coordinate actions to maximize impact; instead, they tend to compete for farmers groups to complete indicators required for their projects = silos, redundancy, and wasting of limited resources.

LANGUAGE AND CULTURAL BARRIERS AFFECT ACCESS TO INFORMATION AND TRAINING

- As a multicultural and multi-lingual country, Guatemala is faced with more serious challenges than other countries in the region, especially considering that small producers of horticulture goods. Producers belong to those communities.

LACK OF AVAILABILITY AND ACCESS TO INFORMATION (CROP SPECIFIC, PRODUCTION PRACTICES, MARKETS)

- There is a lack of access to information related to markets and windows of opportunity, product quality standards, and technical and financial services information.
- Market information is centralized and managed by SIMMPA-Infoagro, not always the required real-time information regarding the offer and demand of horticultural products.
- Market intelligence systems are essential.
- There is not an agricultural policy for horticultural products.
- Research organizations (i.e. FHIA) cannot transfer information due to lack of financial resources, plus it is not within their mandate or budget.
- Growers lack business-oriented approach to horticulture.

- Lack of innovation in horticulture/agriculture.
- Several programs engaged in collecting market price data and planting schedules do not result in the information being generated actually being useful to growers and buyers.
- Updated information (research and training materials) is not available and easily accessed by end users. ICTA only implemented their digital information system until 2003, when finances ceased.
- ICTA offers training to large NGOs but the generation of new technologies is limited due to scarce operational capacity and funding.
- Available weather data is not transformed into weather forecast systems that could minimize/prevent crop damage due to climate events (i.e. freezing in the highlands).
- Practices and methods that result in sustainable production systems (i.e. organic matter incorporation into soils, carbon sequestration strategies, conservation of biological diversity) are not known by farmers, nor are they implemented due to lack of tools/knowledge.
- Proper postharvest handling of produce is not known by small growers or transporters; appropriate handling of product after leaving farm gate is not guaranteed.
- Market quality standards are not always known by growers, which limits linking to larger farmers for export markets.
- Lack of information of price and trends of local and regional markets keeps small growers at a disadvantage.

PHYSICAL

CLIMATE CHANGE RELATED VARIABILITY

- Central America has been recognized as highly susceptible to variable weather-related events such as excess or decreased rain, higher or lower temperatures. These events affect agricultural production, flowering/fruiting cycles and planting dates and increase vulnerability to pests and diseases.
- Small farmers are the most at risk population as their resiliency is low.
- Available insurance policies do not cover climate related events.
- Evidence has been documented that changing climate has forced growers to change crops and cropping systems. For example, FASAGUA indicated that tomato growers are now being displaced to other locations due to pests and diseases, as a consequence of changing climate.

LAND TENURE AND LAND ACCESS ISSUES

- Small growers in Honduras and Guatemala suffer from insufficient suitable land for cultivation, with a 1/2 ha average size; this limits volume and crop expansion. Industrial crops (sugar cane, banana and oil palm) use large areas of agriculture suitable land.

HIGH RISK IN THE HIGHLANDS DUE TO FREEZING TEMPERATURES

- Freezing temperatures during the dry months restrict agricultural activities; however, farmers take the risk and plant vegetables. When freezing occurs, economic losses are absorbed.

WATER AVAILABILITY AND IRRIGATION INFRASTRUCTURE IS LIMITING

- Prolonged dry spells reduce vegetable production and affect fruit production. Water quality, including both microbiological and chemical contaminants, is a serious issue.
- Availability of clean water sources during the dry months is limited.
- Irrigation systems are costly to operate because of clogged pipes and sprinklers.

SOIL EROSION AND LOW FERTILITY ISSUES

- Soil management and conservation are important for controlling erosion problems. Lack of guidelines and education.
- Pressure for land is resulting in more deforestation in the highlands of Guatemala.

SOCIAL

WEAK RURAL HEALTH PROMOTION PROGRAMS

- The issue of undernourished families generally does not seem to be corrected by export-oriented agriculture. In fact, locals sometimes do not know and/or like to eat exported crops.
- Interest in cultivation and consumption of native crops is losing ground to commercial crops.
- Long-term presence of development projects has created dependency of small farmers and their families and communities.

LACK OF KNOWLEDGE OF SOCIOECONOMIC IMPACT OF TECHNOLOGIES AND DEVELOPMENT PROGRAMS

- The socioeconomic impact of technologies developed by ICTA, as well as financial services offered by some organizations, are not known to government bodies, development organizations and the general public.

WEAK ORGANIZATIONAL STRUCTURES AND DISFUNCTIONAL VALUE CHAINS WITH UNDEFINED RULES AND ROLES

- Value chains are not well structured and supported, with clear rules and roles.
- Small farmers are not organized, have low production volumes, and disperse, unscheduled/uncoordinated production
- Small farmers face illegal competition from subsidized imports (onion and potato seeds).
- There is lack of transparency in the value chains, including claims that fair trade does not always benefit the small farmers; intermediaries reap the benefits.
- There is a lack of business attitude approach among farmers with buyers, and producers often fail to abide by contracts.
- National food security policy perpetuates poverty.

LACK OF DIVERSIFIED AGRICULTURAL ACTIVITIES

- Single crop focus (dedication to export agriculture) results in several months without cash flow.

LACK OF WOMEN PARTICIPATION IN COMMERCIAL AGRICULTURE

- Some communities discourage women participation in commercial agriculture, and relegate them to the role of invisible workers.
- Commercially successful enterprises had set rules against women becoming members of the male dominated cooperative.
- In rural areas, some families do not promote/allow education of daughters.

RURAL MIGRATION

- Rural migration to urban centers and to other countries affects labor and families in rural areas.

ILLEGAL MARKET COMPETITION

- Illegal imports of subsidized products displace local produce.
- Potatoes cannot be legally sold in Honduras due to quarantine issues, but are sold illegally, negatively impacting the Honduran market.
- Entrance of imported products (such as pre-cooked potatoes for McDonalds coming from the United States or Canada) has further reduced the market for local produce.
- Not all small farmers have the possibility of selling to Walmart's chain of local supermarkets.
- Deferral of payment (> 45 days) is excessive and some products are rejected when there is surplus.
- Price of fertilizers has increased in the last 2 years, affecting capacity to purchase it, resulting in declining productivity and profitability.
- Contraband coming from Mexico floods the markets, displacing local production.

EXCESSIVE PAPERWORK TO IMPORT/EXPORT AND BUSINESS DEVELOPMENT

- International regulations limit export possibilities; U.S. regulations include labor requirements.
- Paperwork for production and environment permits is excessive, expensive and time-consuming.
- Farmers consider that the regulations of the Ministry of Livestock and Agriculture (MAGA) hamper instead of promoting production.
- Obtaining product certification is difficult; fewer than 150 sanitary operating permits for more than 1 million farmers.

INOPERATIVE AND INEFFICIENT GOVERNMENT OF GUATEMALA (GOG)

- Corruption in GOG. The new government names another person from the party for a position previously held by someone else.
- Corruption in government hiring: the profile only requires the person be unemployed and be associated with the party in office.
- Labor instability: Lack of career positions in government due to changes with administrations following election.
- Extension agents do not have a formal labor contract nor any kind of job security. New extension agents have been hired but their salary has not been paid.

- All extension agents need to be re-hired when the government goes through a change of office.
- The country does not have a national development plan.
- It is not clear how to implement the government´s integrated rural development policy.
- Extension agents got involved in political propaganda activities.
- Even though a sectorial policy has been approved, development projects do not take it into account and the policy itself has not been fully implemented.
- Extension agents do not receive training.

LACK OF STIMULUS THAT PROMOTE PRIVATE SECTOR INVOLVEMENT IN PUBLIC RESEARCH

- The country lacks a public-private model for financing public research. (In Chile, for example, the state pays 40% of the salary of inspection agents.)

BIOLOGICAL

- Limited local capacity for potato seed production.
- Imported seed potato in November causes overproduction some months later.
- Small producers do not produce what the markets demand.
- Vegetative material available to growers is often affected by viruses.
- Lack of sufficiently adequate germplasm bank of fruit varieties that allow variety replacement.
- Pressure from pests and diseases is a major concern in the region, as production costs, productivity, market access and food safety are affected due to this factor.
- There is a limited supply of biological products to control pests and diseases, and when available, are costly.
- Few vegetable seed suppliers; current situation is becoming a monopoly.
- Biannual production cycle of some commercial fruit varieties is not suitable for small farmers; they need alternatives and complementary crops/enterprises.
- Home orchards do not produce local species. Late harvest varieties affect their market opportunities (i.e. rambutan) as other producers (Mexico) enter the market.
- Native crops have received limited attention, and updated information that will be required to make such investment choices is limited.
- Pressure from pests and diseases is a major concern in the region, as production costs, productivity, market access and food safety is affected due to this factor.
- No known rootstocks (i.e. avocado) exist which are tolerant to major diseases.
- Commercial nurseries have not been established for distributing avocado trees grafted onto rootstock exhibiting tolerance to the major root rot diseases.

- Several catastrophic diseases are already affecting the region (HLB in citrus, Lethal yellowing in coconuts, *Fusarium oxysporum* race IV in bananas, *Fusarium* spp. in pineapple, *Tuta* spp. in tomato) and will represent major challenges for small and large farmers.
- Several fruit fly species, which are not included in quarantine barriers, cause major losses for growers but receive little research attention.
- Export crops (rambutan) limited by scale of production capacity.

FOOD SAFETY AND PHYSTOSANITARY CONTRAINTS

- The region is vulnerable to pests and diseases from different sources, and phytosanitary issues of quarantine character, and food safety still affect exports.
- Need for the development of a national program to promote GAPs among small farmers, and provide incentives for updating facilitates.

APPENDIX C: QUESTIONS USED IN WEB SURVEY

(This document has been translated from Spanish to English for the purposes of this report.)

Evaluation of the Horticulture Sector in Latin America

Introduction and justification

Evaluation of constraints to the growth of the horticultural sector

PROJECT JUSTIFICATION
Since the mid-1980s, USAID has made significant investments in Latin America and the Caribbean (LAC) to develop agricultural industries exporting non-traditional products, including investments in production, pest management, postharvest handling, and processing and marketing of horticultural products with added value. As a result of these investments, the export of high value crops and product value added has generated an increased volume of international trade and contributed to growth of GDP. This has given producers and other agricultural business more opportunities to generate jobs with higher incomes. With the adoption of free trade agreements between countries in the LAC region and the United States, an urgent need has arisen to develop sustainable cropping systems (including best strategies for pest management). Such systems should focus on increasing production, improving postharvest management, and increasing fruit and vegetable crop processing so as to add value and facilitate marketing. The goal of these objectives is to increase the competitiveness of countries prioritized by the "Feed the Future" initiative giving them greater access to regional and international markets. To achieve this level of growth and competitiveness, in the horticultural sector, however, immediate investment is needed in two areas: (a) Generation and dissemination of the technologies and horticultural knowledge required to overcome factors limiting sustainable production and profitability for horticultural crops, (b) An institutional support system that facilitates the delivery of resources and services required producers to produce quality crops and products that meet the demands market and regulatory standards of that market.

Elizabeth Mitcham,
Director
Horticulture Collaborative Research Support Program
U.C. Davis

Assessment of the Horticulture Sector in Central America
Basic information
Questions 1 through 4 provide information on your role

1. Basic Information about the Respondent
Full name:
Sex: M F
City / Town:
State / Prov.:
Country:
E-mail

2. Basic information on your background. Select the most appropriate and complete the underlined space
Professional in______________________________
Extension agent in______________________________
Technician in______________________________
Student of______________________________
Distributor and trader of______________________________
Producer of______________________________
Other______________________________

3. Which type of organization do you belong to. You can mark more than one if necessary.
NGO___
Government___
Academia___
National or International Research Institute ___
Producers Organization___
Consultant___
Agency for International Development___
Independent___
Other___
Horticulture Sector Assessment in Central America

4. What area do you work in?.
Agricultural production____
Marketing____
Research____
Consulting____
Extension and training____
Education____
Government regulatory organization____
Supplier (agrochemicals, seeds, sprinkler systems, etc.) ____
Other____

5. Of the following factors related to horticultural production, assign a value that describes whether it is a limiting constraint to horticulture in your geographic area. 1 is the least limiting and 5 is extremely limiting.

	1	2	3	4	5	Don't know
Technical capacity of producers	[___]	[___]	[___]	[___]	[___]	[___]
Quality of technical assistance offered to producers	[___]	[___]	[___]	[___]	[___]	[___]
Availability of chemicals	[___]	[___]	[___]	[___]	[___]	[___]
Cost of chemicals	[___]	[___]	[___]	[___]	[___]	[___]
Availability of biological control for pests and diseases	[___]	[___]	[___]	[___]	[___]	[___]
Cost of biological control of pests and diseases	[___]	[___]	[___]	[___]	[___]	[___]
Access to new varieties resistant to pests & diseases	[___]	[___]	[___]	[___]	[___]	[___]
Availability of certified planting material	[___]	[___]	[___]	[___]	[___]	[___]
Availability of irrigation technologies	[___]	[___]	[___]	[___]	[___]	[___]
Cost of irrigation technologies	[___]	[___]	[___]	[___]	[___]	[___]
Public irrigation district	[___]	[___]	[___]	[___]	[___]	[___]
Illegal entry of agricultural products	[___]	[___]	[___]	[___]	[___]	[___]
Lack of time for production, marketing, and family	[___]	[___]	[___]	[___]	[___]	[___]

Other (specify)____

6. Of the factors related to markets and policies, assign a value that describes whether it is a limiting constraint to horticulture horticulture in your geographic area. 1 is the least limiting and 5 is extremely limiting.

	1	2	3	4	5	Don't know
Lack of government programs to support small agricultural producers	[___]	[___]	[___]	[___]	[___]	[___]
Access to credit for small producers	[___]	[___]	[___]	[___]	[___]	[___]
Cost of credit for agriculture	[___]	[___]	[___]	[___]	[___]	[___]
Availability of agricultural insurance	[___]	[___]	[___]	[___]	[___]	[___]
Cost of agricultural insurance	[___]	[___]	[___]	[___]	[___]	[___]
Trust and transparency in the value chain	[___]	[___]	[___]	[___]	[___]	[___]

Welfare culture of development programs in the region	[___]	[___]	[___]	[___]	[___]	[___]
Producer associations	[___]	[___]	[___]	[___]	[___]	[___]
Access to market information	[___]	[___]	[___]	[___]	[___]	[___]
Access to informal markets	[___]	[___]	[___]	[___]	[___]	[___]
Access to formal markets	[___]	[___]	[___]	[___]	[___]	[___]
Access to export markets	[___]	[___]	[___]	[___]	[___]	[___]
Payment policies in formal markets	[___]	[___]	[___]	[___]	[___]	[___]
Availability of land suitable for agriculture	[___]	[___]	[___]	[___]	[___]	[___]
Security of land tenure (invasions, expropriations)	[___]	[___]	[___]	[___]	[___]	[___]
Other (specify)______________________________						

7. In relation to weather-related factors, assign a value that describes whether it is a limiting constraint to horticulture in your geographic area. 1 is the least limiting and 5 is extremely limiting.

	1	2	3	4	5	Don't know
Prolonged periods without rain	[___]	[___]	[___]	[___]	[___]	[___]
Increased rainfall	[___]	[___]	[___]	[___]	[___]	[___]
Flooding of production areas	[___]	[___]	[___]	[___]	[___]	[___]
Landslides blocking access to growing areas	[___]	[___]	[___]	[___]	[___]	[___]
Effects of high temperatures on the crops	[___]	[___]	[___]	[___]	[___]	[___]
Low temperature extremes (frost)	[___]	[___]	[___]	[___]	[___]	[___]
Increased pest populations and diseases	[___]	[___]	[___]	[___]	[___]	[___]
Presence of new pests and diseases	[___]	[___]	[___]	[___]	[___]	[___]
Other (specify)______________________________						

Questions 9-12 are related to aspects of markets and marketing of horticultural products. Questions 14 through 19 are related to research aspects. You have the option to answer one section, both sections, or to exit survey.

8. Do you want to answer the questions on marketing and markets?
If
[___] Yes

[___] I wish to respond to questions on research

[___] I want to exit the survey

9. • Select market channels you use to sell your products. Select all that apply to you.
[___] I sell to a broker directly, because it is important for me and he treats me fairly.
[___] I sell to the broker directly, because I have NO other marketing channel.
[___] I am a member of a cooperative and we sell our product as a cooperative
[___] I sell my products directly in farmer's markets or green markets in the suburbs
[___] I sell my own products in wholesale markets.
[___] I have contract with large-scale supermarkets
[___] I sell to larger producers who have better contacts with marketers.
Other (specify)__________________________________

10. Of the mechanisms listed below, which you consider would result in a fair and stable price for producers in informal markets. Select the one that you think is most appropriate:

[___] Staggered plantings to avoid seasonal gluts
[___] Forming producer associations to market cooperatively
[___] Establish commercial companies to sell products.
[___] Establish agreements or contracts with vendorsin the wholesale markets.
[___] Use the marketing services of non-governmental organizations

Other (specify)____

11. To improve business relations between producers and marketers of fruits and vegetables, do you think the state could: (select the answer you consider most appropriate).

[___] Implement policies ensuring prompt payment to the producer.
[___] Establish stricter price control laws.
[___] Establish more collection centers.
[___] Establish business centers to facilitate contact between producers and marketers
[___] Provide training in agribusiness for producers and marketers.
Other (specify)____

12. • Do you think that non-governmental organizations could improve relations between producer and distributor, by offering: (Select the answer you consider most appropriate)
[____] Agribusiness training for various segments of the distribution chain (producer, intermediary, carrier, wholesale buyer, supplier of inputs).
[____] Market intelligence to producers.
[____] Marketing services to producers.
[____] Improved relationships btween producer and marketer through trade fairs, business conferences, etc.
Other (specify)____

13. Do you want to answer questions 14-19 related to research topics?
[____] Yes
[____] No

The next section (questions 14-19) will identify research needs in various subjects relevant to horticulture. Please select relevant responses for each question

14. Identify your area of research. Select all that apply to you

[___] Breeding
[___] Crop management, agronomy and physiology
[___] Water management in plant production
[___] Adaptation and management of protected agriculture crops
[___] Integrated management of pests and diseases
[___] Optimization of production systems
[___] Management of soil and nutrients
[___] Tissue Culture / Biotechnology
[___] Postharvest handling
[___] Food Engineering
[___] Sociology and Rural Development
[___] Agricultural Economics
[___] Policy Development
[___] Business Development / Market Access
[___] Extension and knowledge management
Other (specify)____

15. Please rate the factors below in terms of importance to perform their work

	1	2	3	4	5	Don't know
Availability of funds for research	[____]	[____]	[____]	[____]	[____]	[____]
National system of research funding	[____]	[____]	[____]	[____]	[____]	[____]
Requests for research proposals	[____]	[____]	[____]	[____]	[____]	[____]
Ability to establish collaborative projects with advanced						

research institutes	[___]	[___]	[___]	[___]	[___]	[___]
Allocation of time by your institution for conducting Research	[___]	[___]	[___]	[___]	[___]	[___]
That your research addresses the rural development program for the region	[___]	[___]	[___]	[___]	[___]	[___]
That the results of your research are transferred to the end user	[___]	[___]	[___]	[___]	[___]	[___]
That your research stimulates innovation	[___]	[___]	[___]	[___]	[___]	[___]
That research is funded by private industry	[___]	[___]	[___]	[___]	[___]	[___]
Other (specify)________________________						

16. In your view, research priorities in management of pests and diseases should be. Select all that apply.
[___] Integrated pest and disease management
[___] Alternative methods for control of fruit fly (export crops)
[___] Alternative methods for control fruit fly (indigenous fruit and vegetable species)
[___] Population dynamics of introduced or migratory species
[___] Virus identification and management
[___] Thrips palmi
[___] Biological control of palm weevil (R palmarum)
[___] Lethal Yellowing of coconut
[___] Development of biological control agents
[___] Commercialization and accessibility of biological control agents
[___] Registration of pesticidess for fruits and vegetables
[___] Effect of mixed farming systems on pests and diseases
[___] Management of Fusarium in banana and plantain
[___] Anthracnose management alternatives
[___] Avocado root rot (Phytophthora cinnamomi)
[___] Rambutan Scale
Other (specify) ________________________

17. In your view, research on issues of Crop Production and Management should include:
[___] Management of crops under protected agriculture
[___] Development of new varieties adapted to climate change
[___] Development of an early warning system for climate changes
[___] Conservation and optimal management of soils
[___] Integrated Production Systems
[___] Sustainable production systems
[___] Availability of certified planting material
[___] Regulation of nurseries and seed distribution systems
[___] Optimization of irrigation and plant nutrition
[___] Resilience of production systems to climate change
Other (specify)________________________

18. Biotechnology is conceptualized as the ability to develop useful products from biological organisms or derived from biological processes. In your view, research in Biotechnology should be directed to:

[___] Optimizing transformation and regeneration protocols
[___] Somatic embryogenesis in tree and palms species
[___] Development of genetically modified organisms (GMOs)
[___] Development of endophytic organisms to counter pests and diseases
[___] Development of low-cost tissue culture systems
[___] Developing bioles (sic)
[___] Use of microorganisms to control pests and diseases (fungi, bacteria, viruses)
Other (specify)________________________

19. In postharvest research, the priority themes should be:
[___] Postharvest handling (cold chain, quarantine treatment, controlled atmosphere) of products indigenous to native to Central America with export potential
[___] Managing the cold chain for export products
[___] Low cost quarantine treatments
[___] Optimizing crop management to optimize postharvest quality
[___] Ensuring safety and defining Maximum Residue Limits for commercial agrichemicals
[___] Radiation treatments for export agriculture
[___] Development of processed products using native species
Other (specify)____

20. These people might also be interested in taking the survey.
Name
Mail (email)
Name
Electronic Mail (email)
Name
Electronic Mail (email)
Name
Electronic Mail (email)
Name:
E-mail (email):

Dear colleagues, thank you very much for your time and dedication in completing the survey. Remember the results of this study will be available on the website of the Horticulture CRSP (Http://hortcrsp.ucdavis.edu/LAC/) in early April, 2013.

End of Survey

APPENDIX D: ANALYSIS OF WEB SURVEY

Análisis de los resultados de la encuesta.
7 personas solo contestaron las preguntas básicas
15 personas respondieron las preguntas de mercado
Sin discriminar por país, las variables que fueron consideradas como Extremadamente Limitantes se listan de mayor a menor:

Factors considered as extremely limiting by those surveyed
Acceso a crédito para los pequeños productores (as)
Costo del crédito para la agricultura
Disponibilidad del seguro agrícola
Costo del seguro agrícola
Acceso a mercados de exportación
Falta de programas del gobierno que apoyen la agricultura del pequeño productor (a)
Ingreso ilegal al país de productos agrícolas

Factors considered as very limiting by those surveyed:
Acceso a mercados formales
Falta de acceso a nuevas variedades resistentes a plagas y enfermedades
Acceso a información de mercados
Incremento de las poblaciones de plagas y enfermedades
Costo de tecnologías de riego
Calidad de asistencia técnica ofrecida a productores
Costo de productos biológicos para control de plagas y enfermedades
Distrito de riego público
Confianza y transparencia en la cadena de valor
Presencia de nuevas plagas y enfermedades en el cultivo
Asociatividad de productores (as)
Disponibilidad de tecnologías de riego
Disponibilidad de material de siembra certificado
Disponibilidad de productos biológicos para control de plagas y enfermedades

Factores considered as limiting by those surveyed:
Incremento en las lluvias
Períodos prolongados de falta de lluvias
Capacidad tecnica de los productores
Inundaciones en los campos de producción
Deslices de tierra y bloqueo de vías de acceso
Costo de insumos químicos
Disponibilidad de tierras aptas para la agricultura
Cultura asistencialista de programas de desarrollo en la región
Politica de pago de los mercados formales
Seguridad en la tenencia de la tierra (invasiones, expropiaciones)

Those surveyed were asked to rank the factors that were most relevant for them to perform their work.

Factors ranked as extremely important by those surveyed:

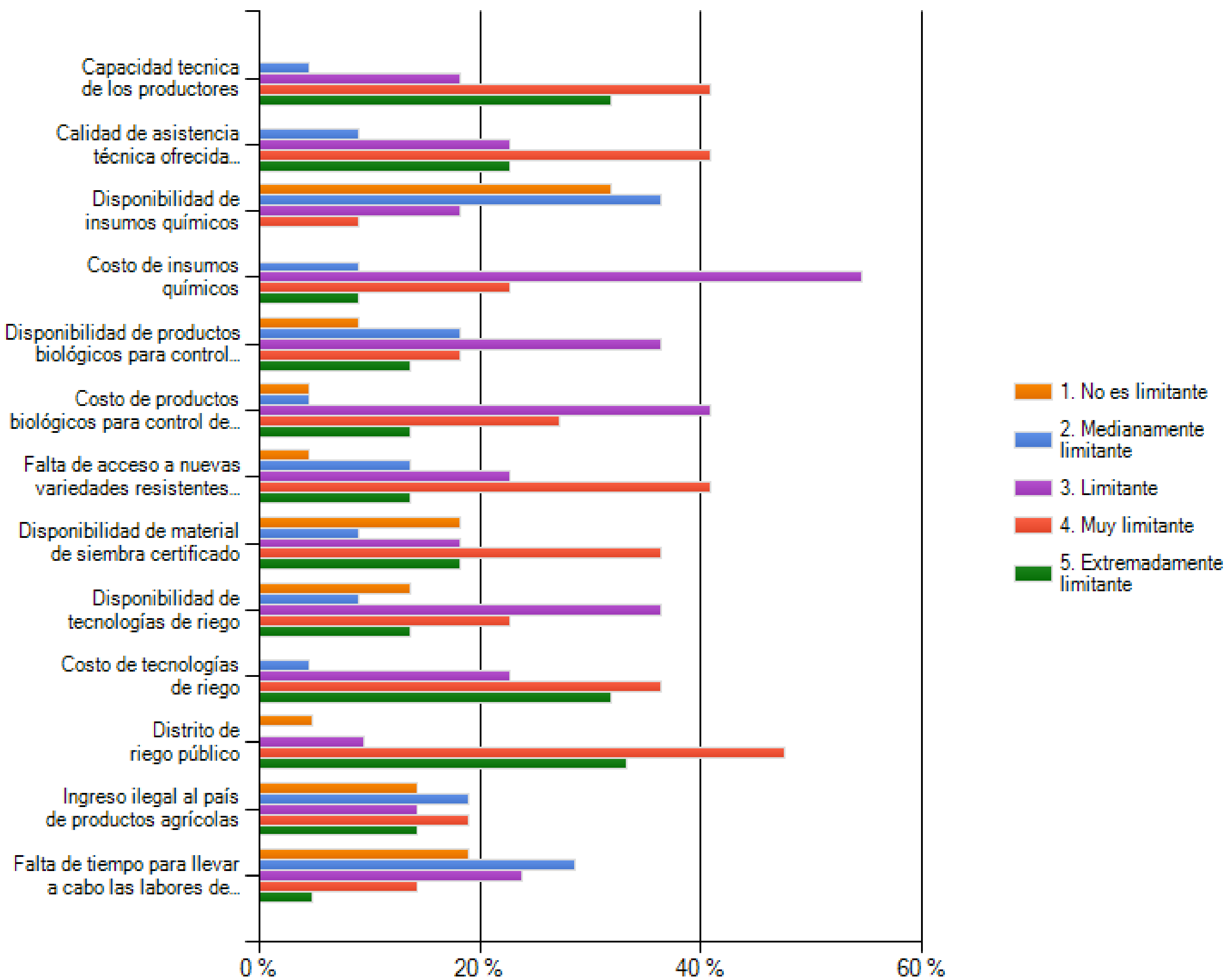
Que los resultados de su investigación sean transferidos al usuario final
Disponibilidad de fondos para la investigación
Que la investigación que realiza de origen a procesos de innovación
Que la investigación que realiza responda a los programa de desarrollo rural en la región
Sistema nacional de financiación de la investigación
Asignación de tiempo por parte de su institución para realizar investigación

Factors ranked as very important by those surveyed:

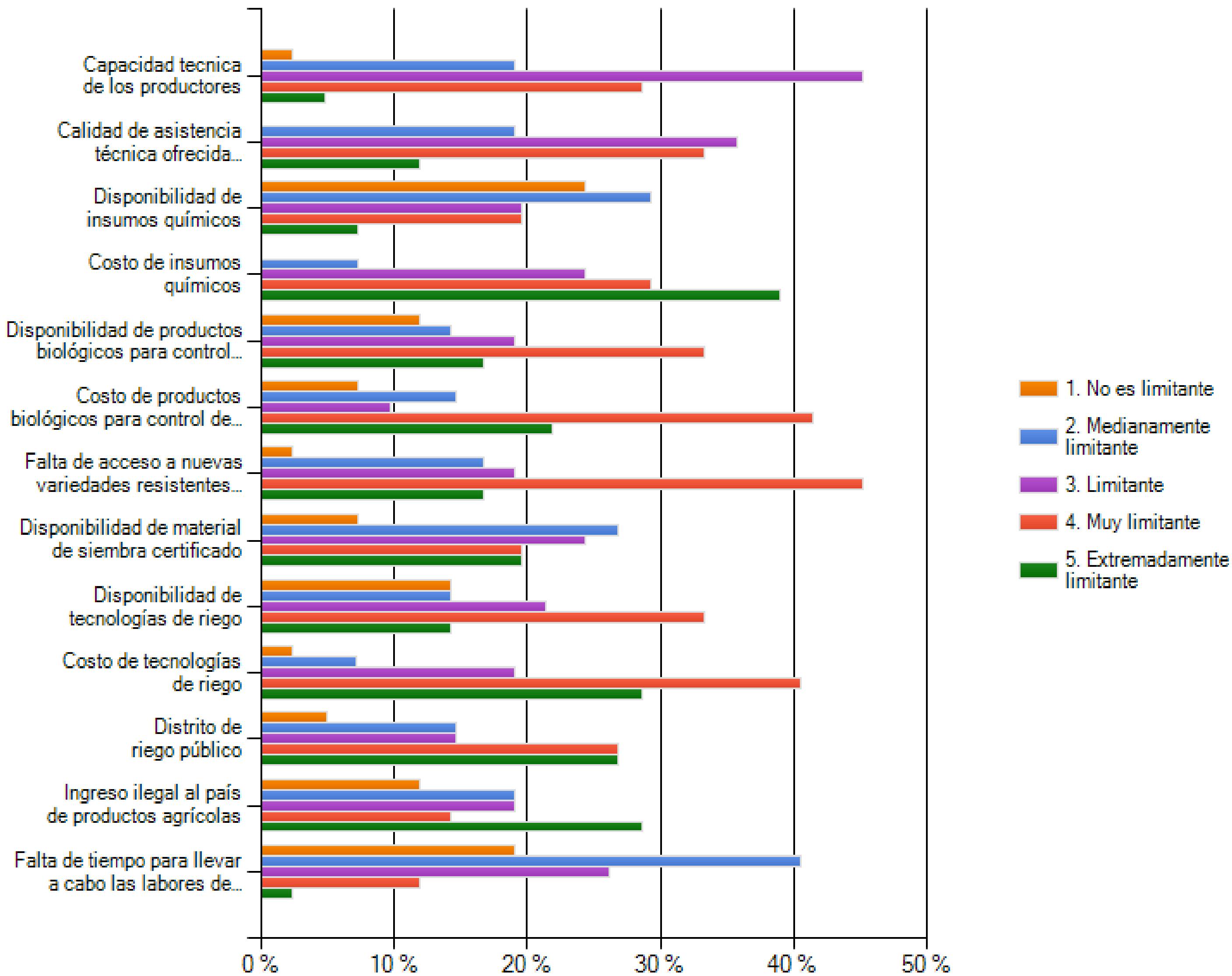
Llamadas a financiación de proyectos de investigación
Capacidad para establecer proyectos colaborativos con institutos de investigación avanzada

APPENDIX E: SURVEY RESPONSES

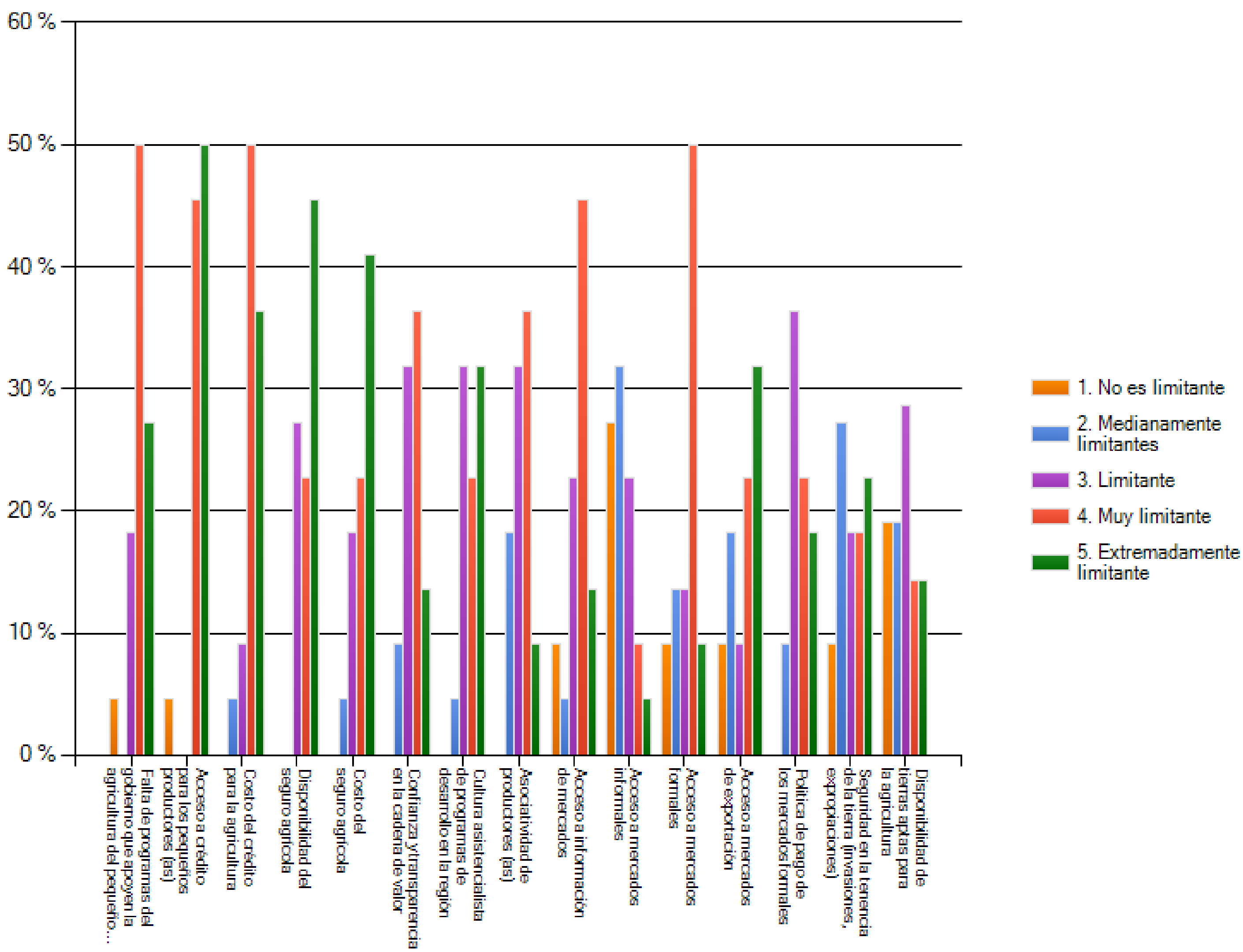
Q5 Guatemala



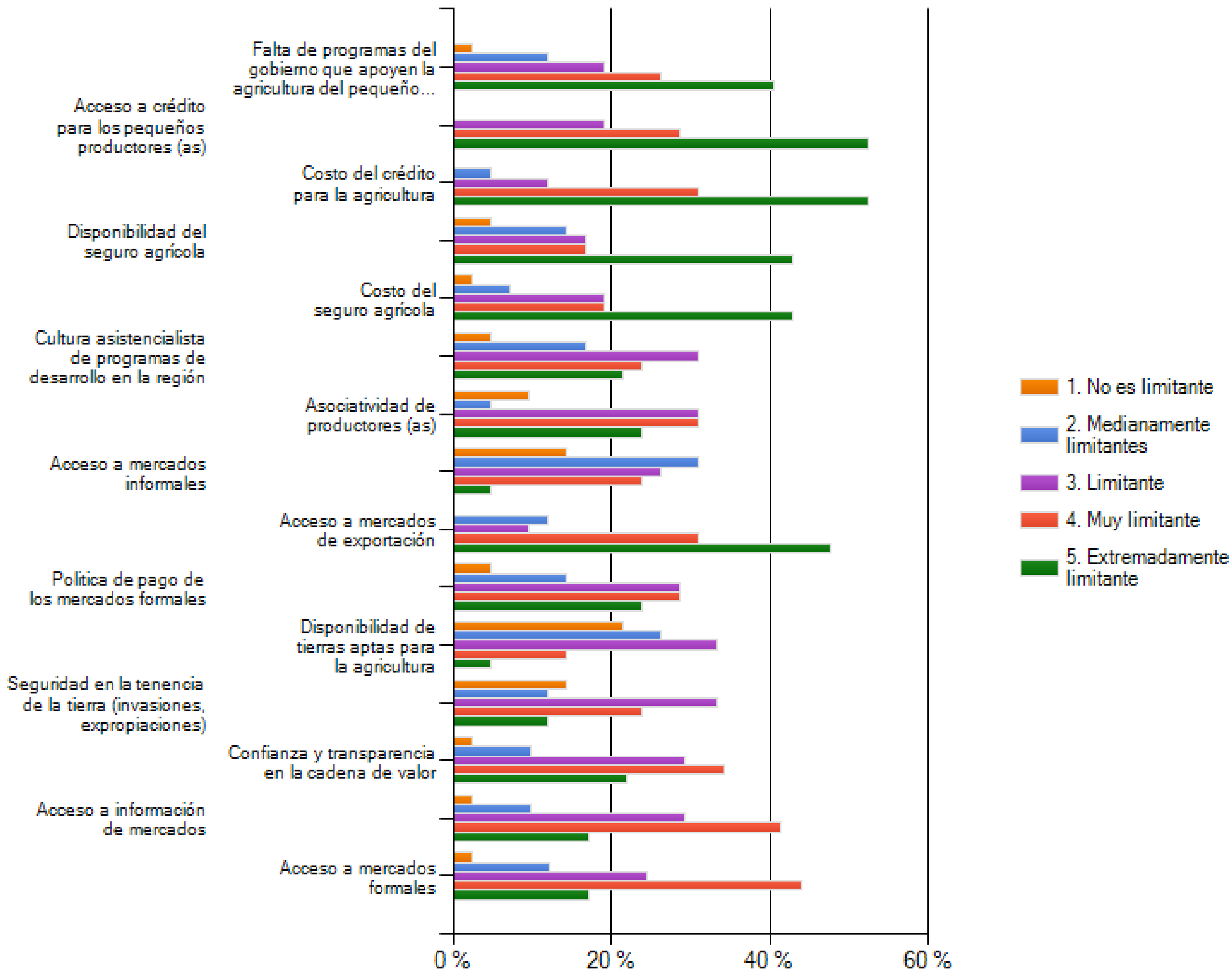
Q5 Honduras


Capacidad tecnica de los productores
Calidad de asistencia técnica ofrecida...
Disponibilidad de insumos químicos
Costo de insumos químicos
Disponibilidad de productos biológicos para control...
Costo de productos biológicos para control de...
Falta de acceso a nuevas variedades resistentes...
Disponibilidad de material de siembra certificado
Disponibilidad de tecnologías de riego
Costo de tecnologías de riego
Distrito de riego público
Ingreso ilegal al país de productos agrícolas
Falta de tiempo para llevar a cabo las labores de...
0 %
10 %
20 %
30 %
40 %
50 %
1. No es limitante
2. Medianamente limitante
3. Limitante
4. Muy limitante
5. Extremadamente limitante

Q6 Guatemala

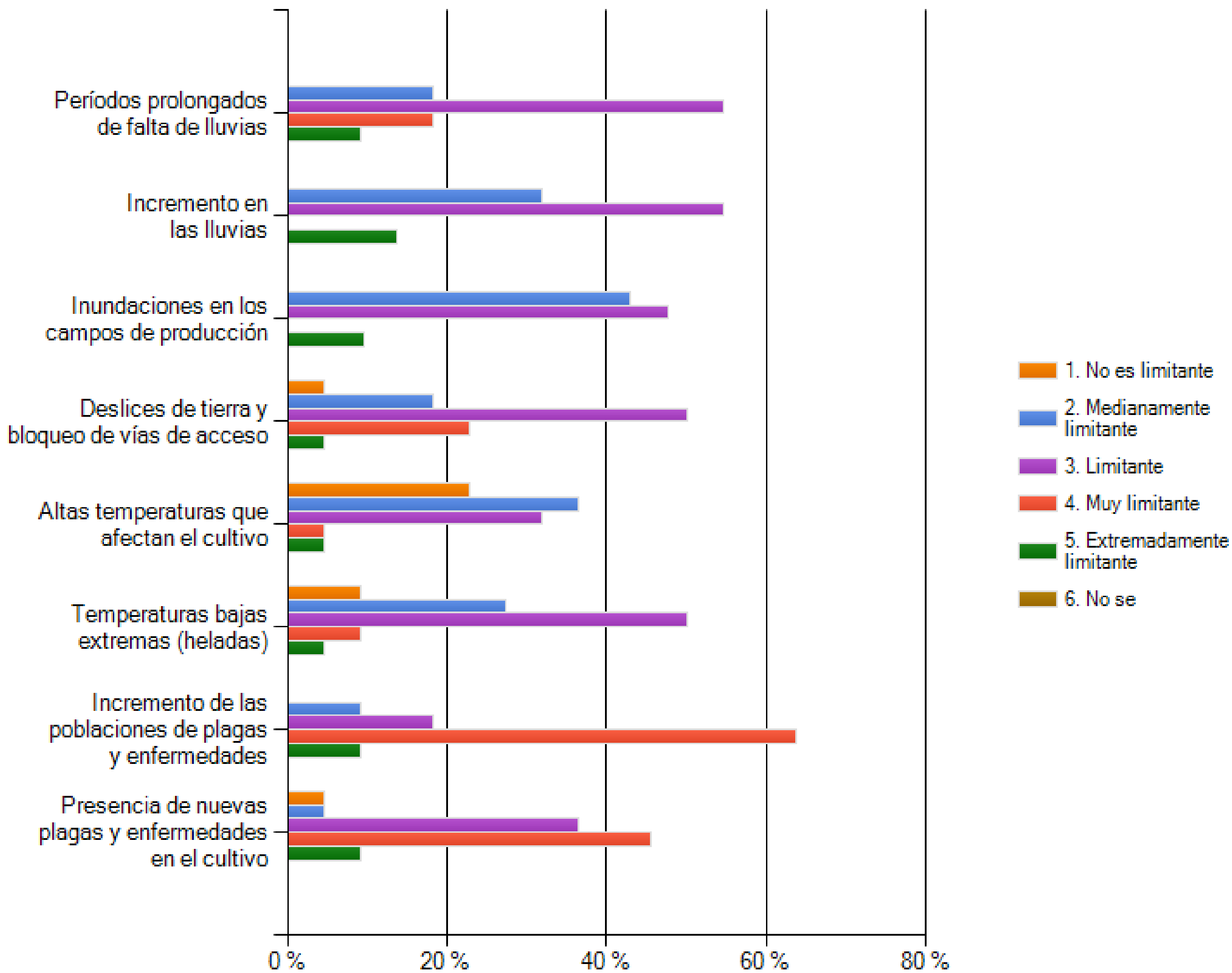


Q6 Honduras

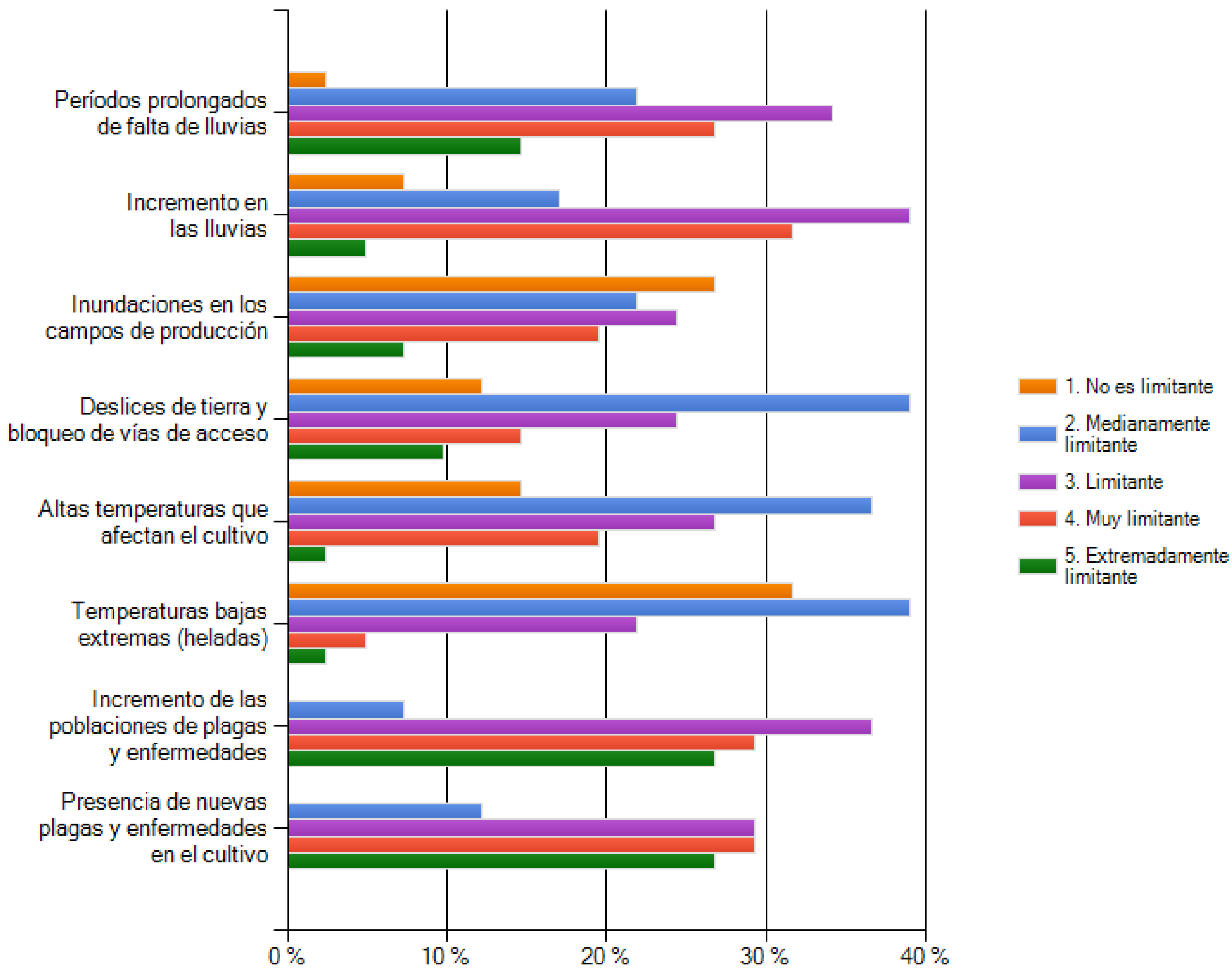


Falta de programas del gobierno que apoyen la agricultura del pequeño...
Acceso a crédito para los pequeños productores (as)
Costo del crédito para la agricultura
Disponibilidad del seguro agrícola
Costo del seguro agrícola
Cultura asistencialista de programas de desarrollo en la región
Asociatividad de productores (as)
Acceso a mercados informales
Acceso a mercados de exportación
Política de pago de los mercados formales
Disponibilidad de tierras aptas para la agricultura
Seguridad en la tenencia de la tierra (invasiones, expropiaciones)
Confianza y transparencia en la cadena de valor
Acceso a información de mercados
Acceso a mercados formales
0 %
20 %
40 %
60 %
1. No es limitante
2. Medianamente limitantes
3. Limitante
4. Muy limitante
5. Extremadamente limitante

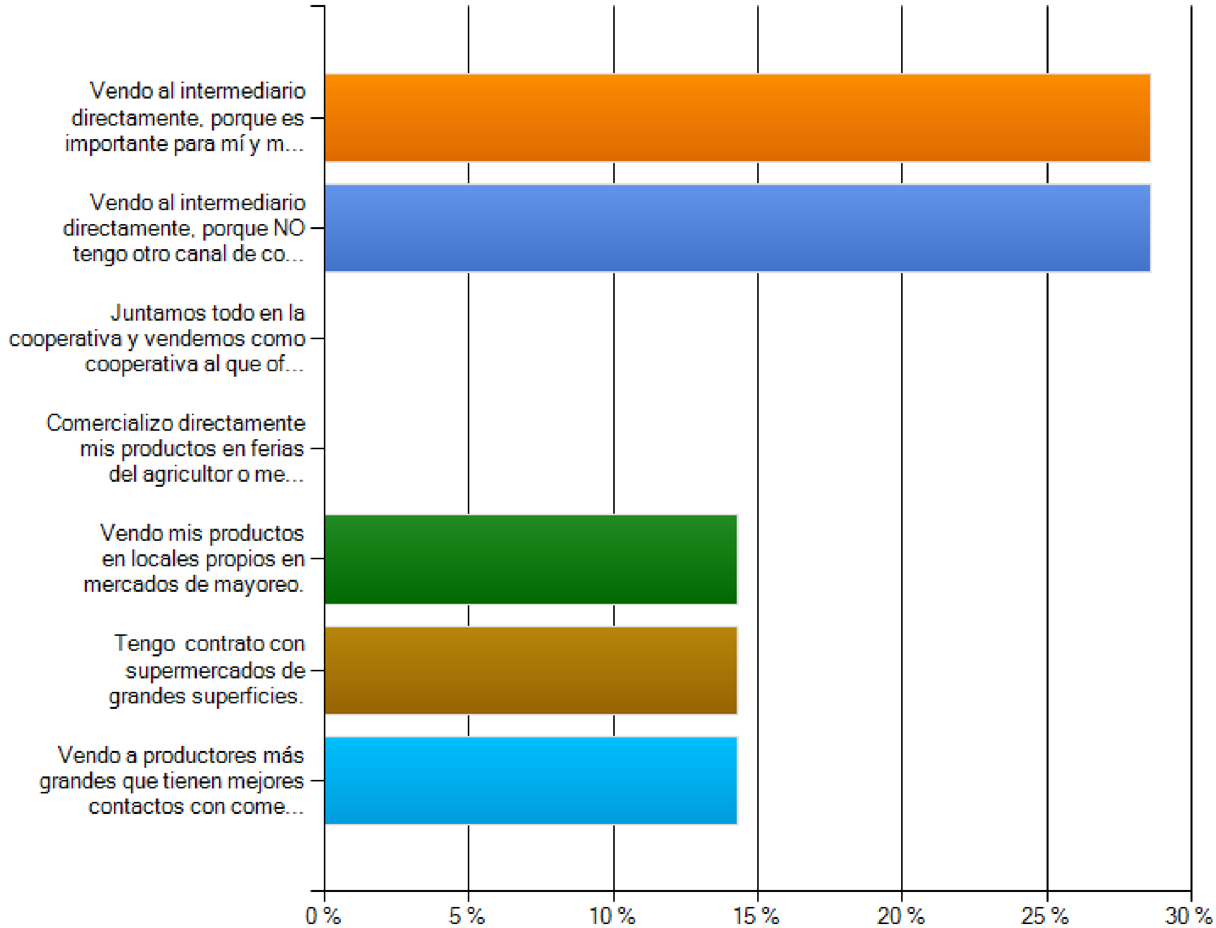
Q7 Guatemala



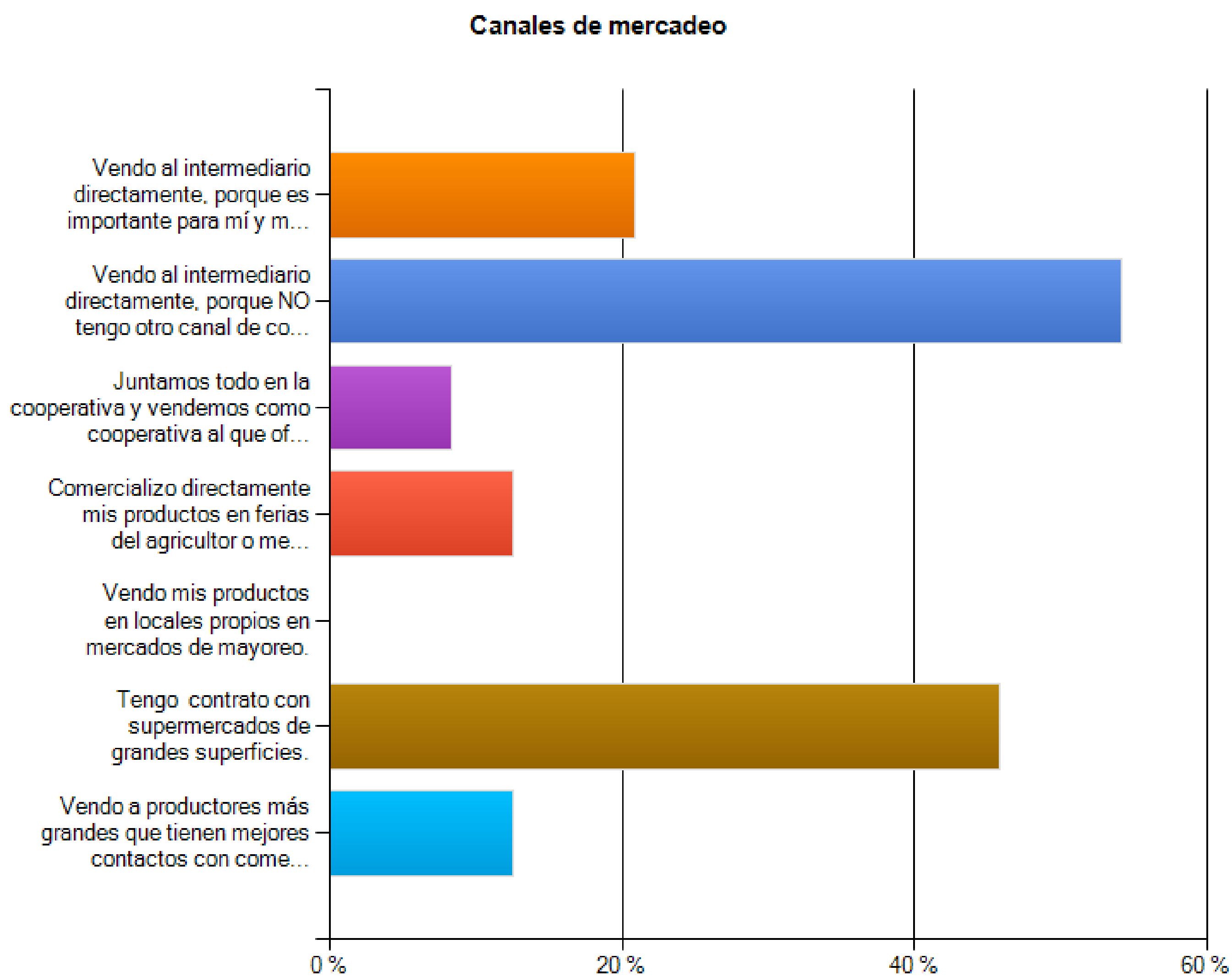
Q7 Honduras


Períodos prolongados de falta de lluvias
Incremento en las lluvias
Inundaciones en los campos de producción
Deslices de tierra y bloqueo de vías de acceso
Altas temperaturas que afectan el cultivo
Temperaturas bajas extremas (heladas)
Incremento de las poblaciones de plagas y enfermedades
Presencia de nuevas plagas y enfermedades en el cultivo
0 %
10 %
20 %
30 %
40 %
1. No es limitante
2. Medianamente limitante
3. Limitante
4. Muy limitante
5. Extremadamente limitante

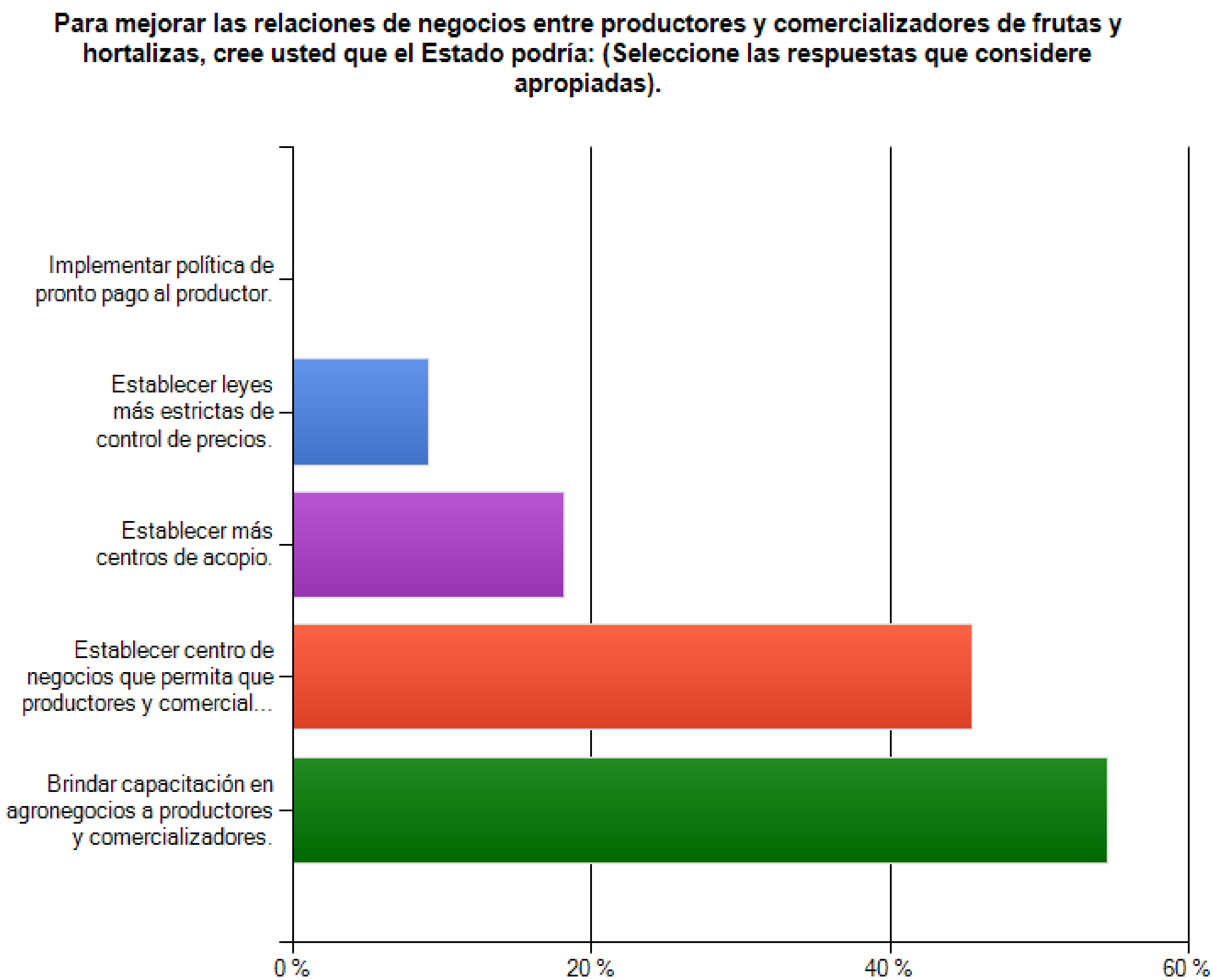
Q9 Guatemala



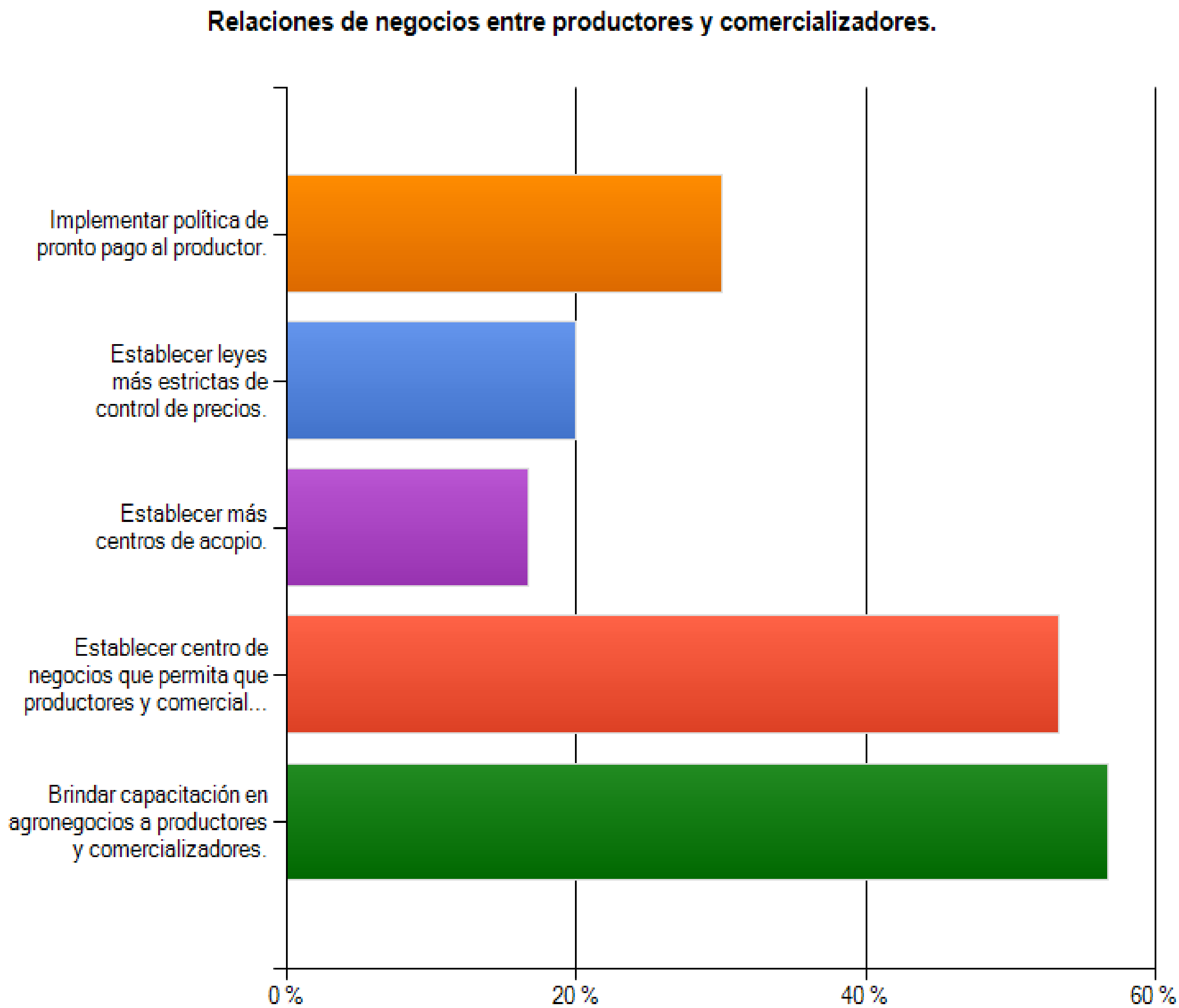
Q9 Honduras


Canales de mercadeo
Vendo al intermediario directamente, porque es importante para mí y m...
Vendo al intermediario directamente, porque NO tengo otro canal de co...
Juntamos todo en la cooperativa y vendemos como cooperativa al que of...
Comercializo directamente mis productos en ferias del agricultor o me...
Vendo mis productos en locales propios en mercados de mayoreo.
Tengo contrato con supermercados de grandes superficies.
Vendo a productores más grandes que tienen mejores contactos con come...
0 %
20 %
40 %
60 %

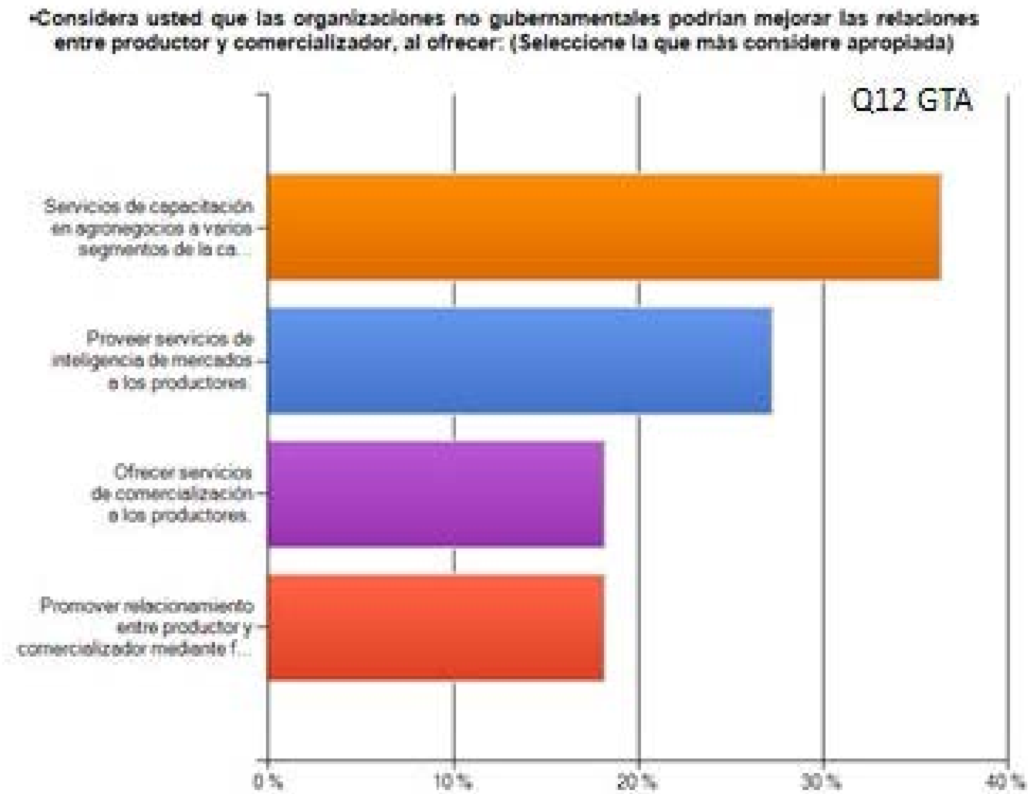
Q11 Guatemala



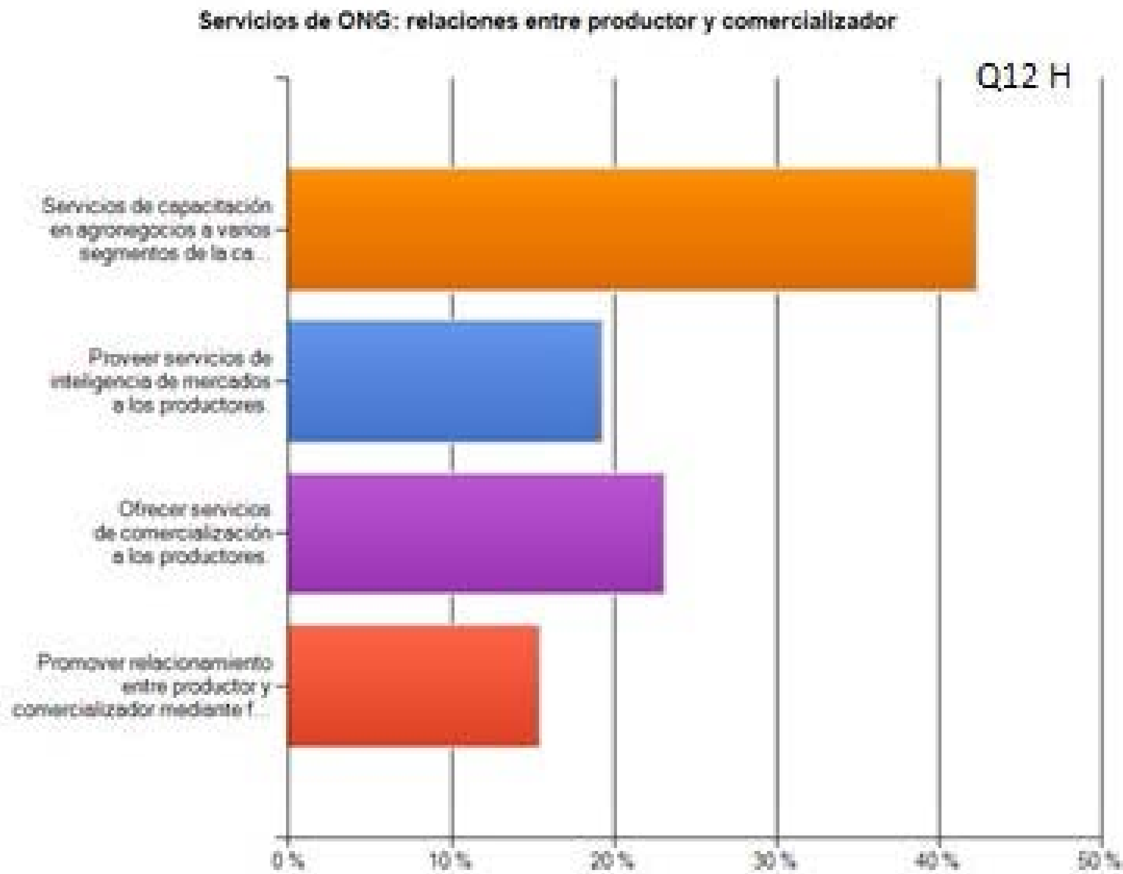
Q11 Honduras



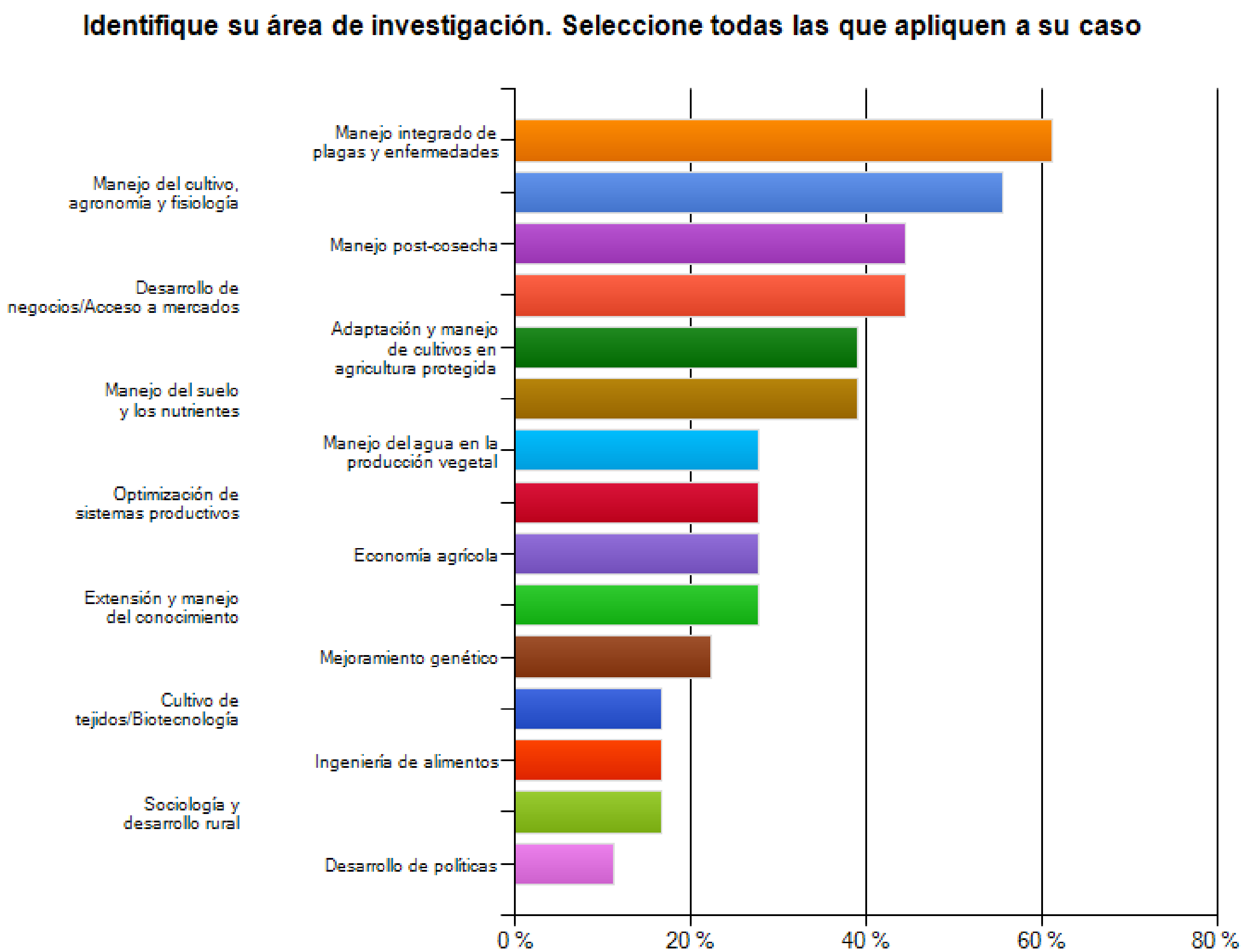
Q12 Guatemala



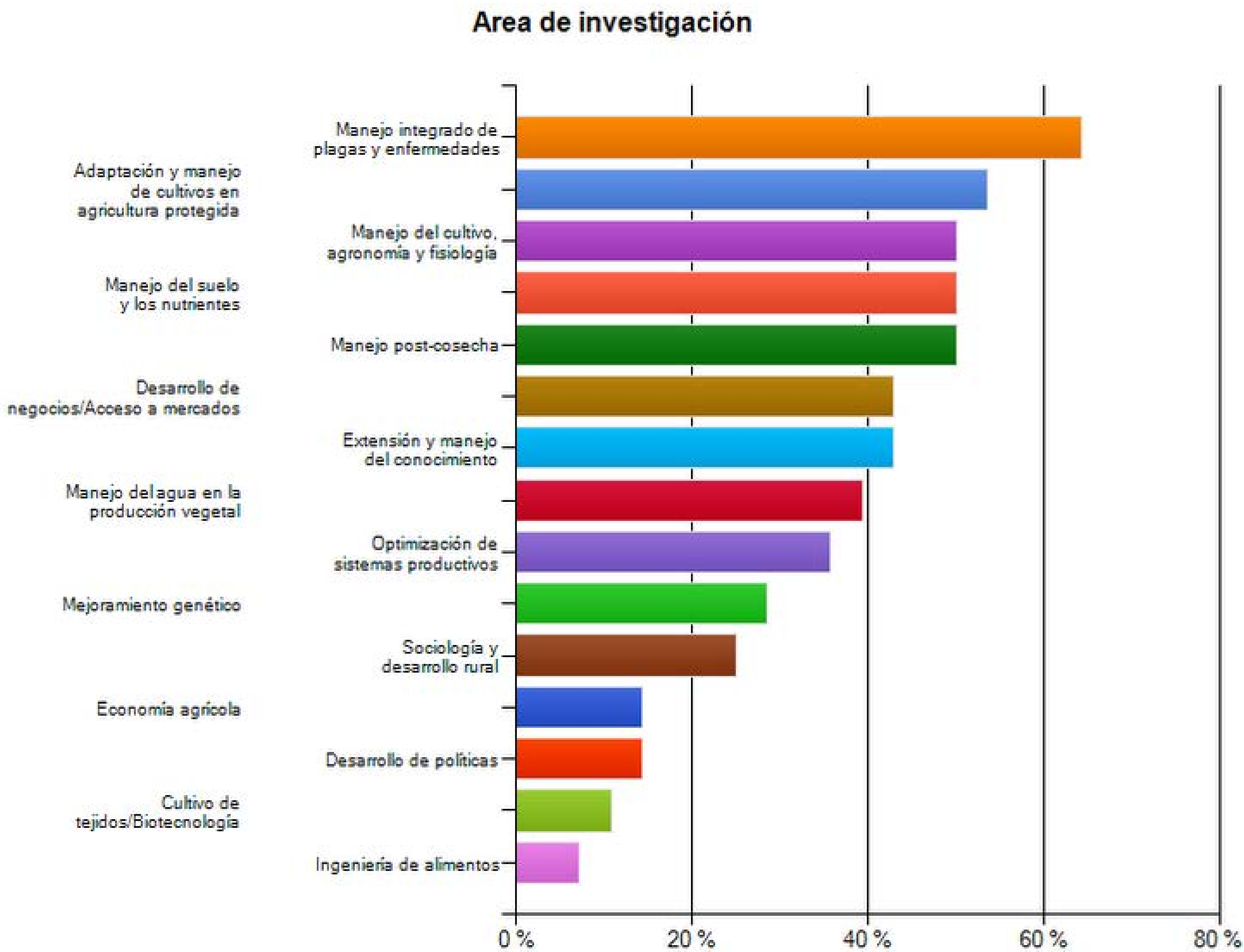
Q12 Honduras



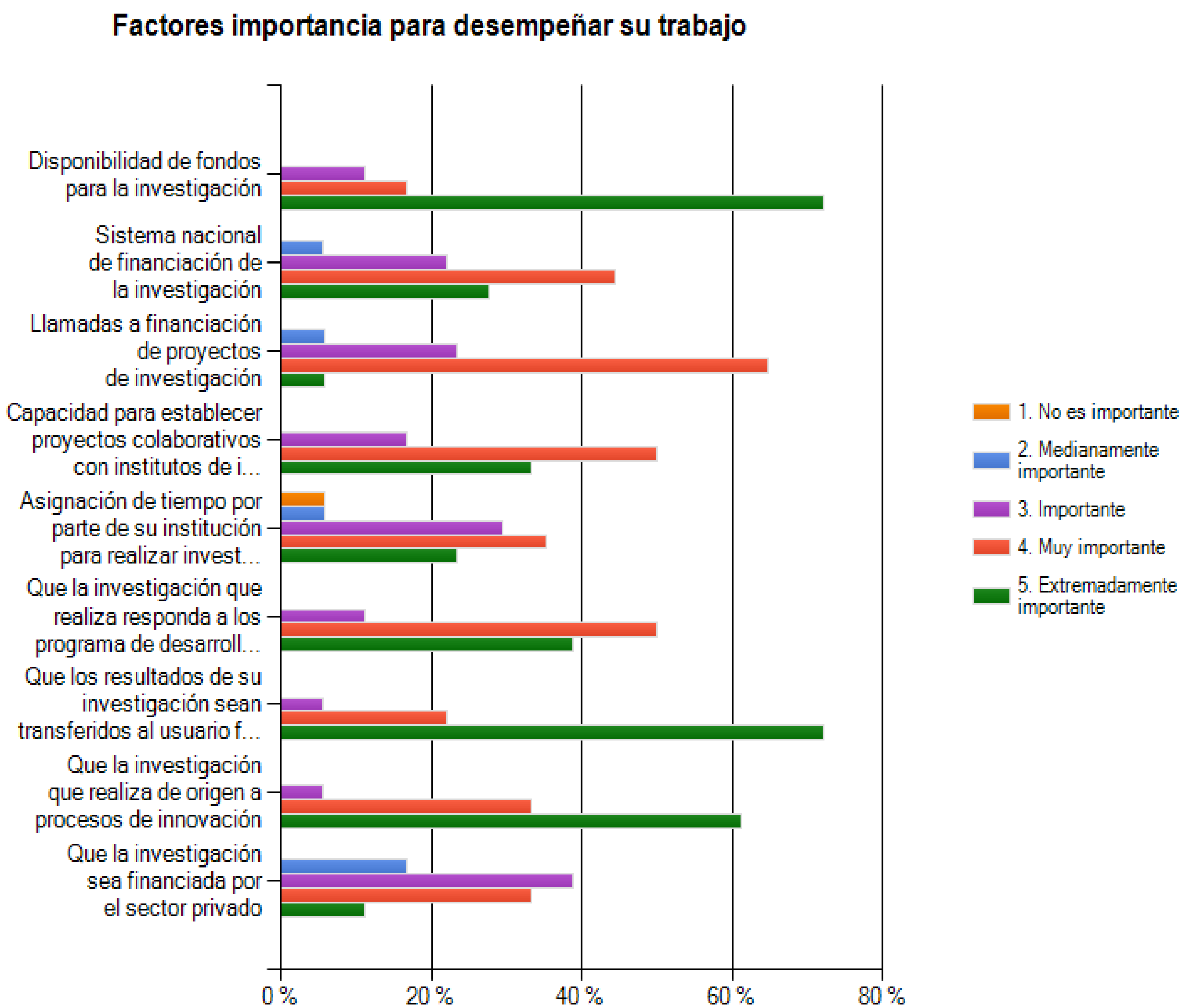
Q14 Guatemala



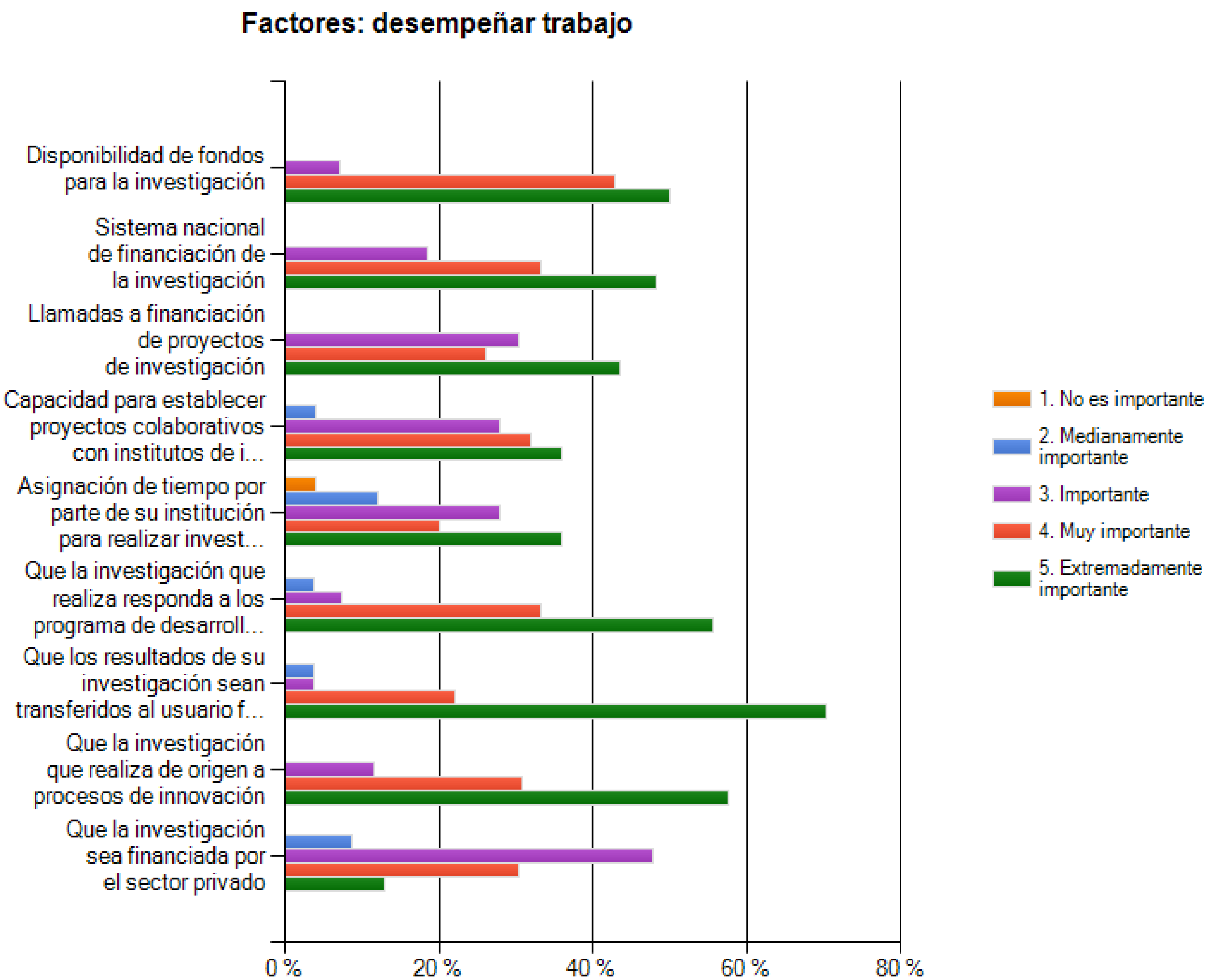
Q14 Honduras



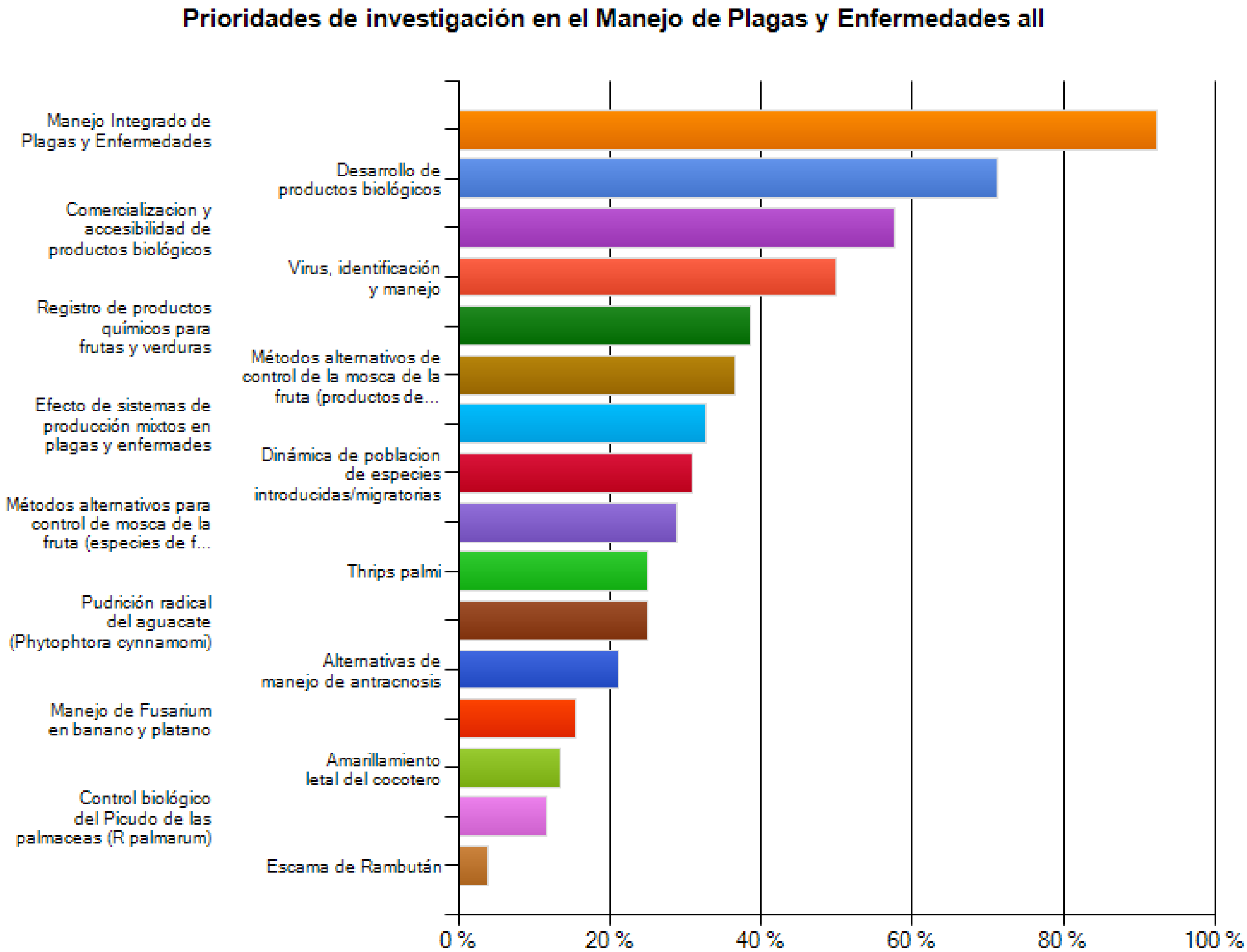
Q15 Guatemala



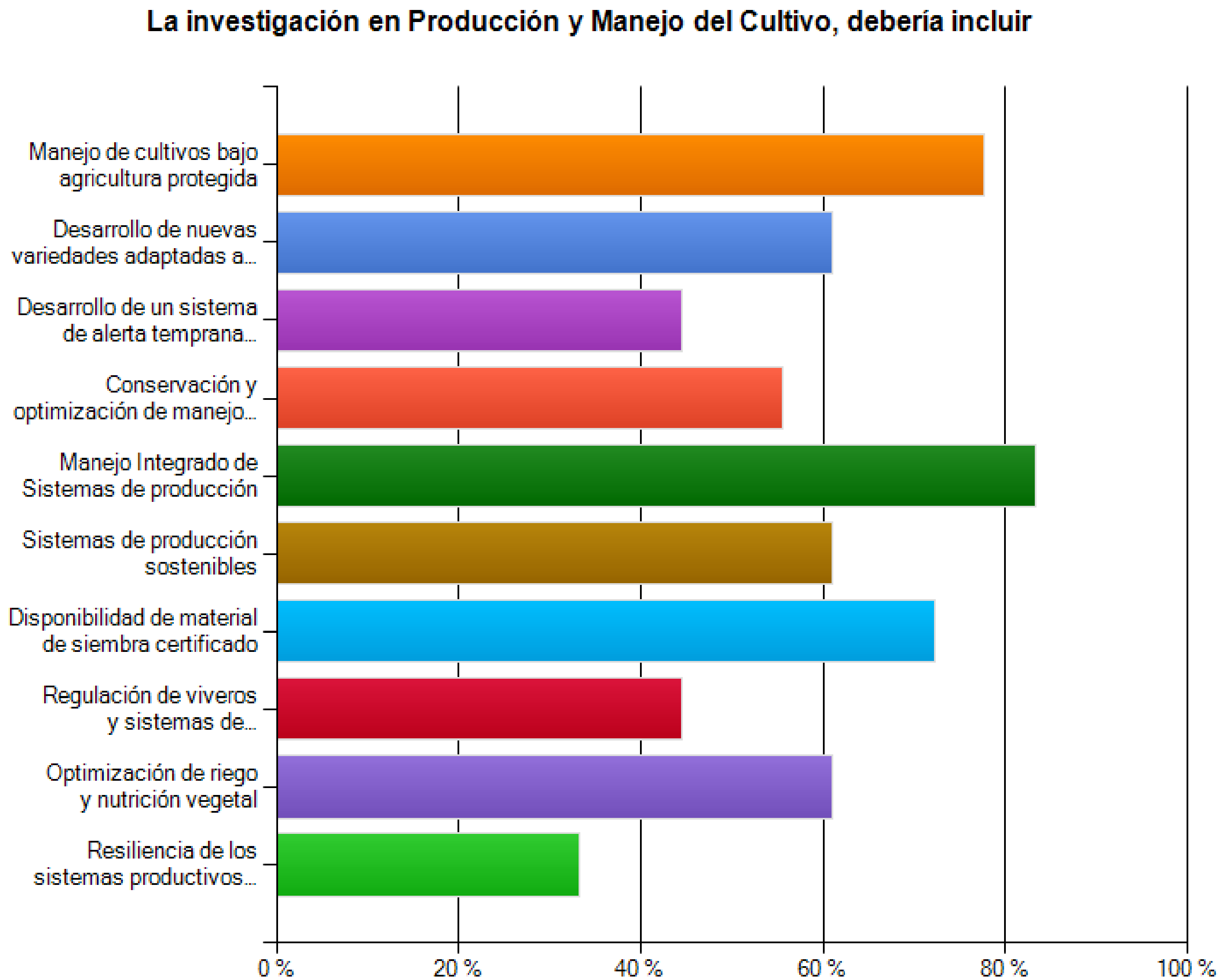
Q15 Honduras



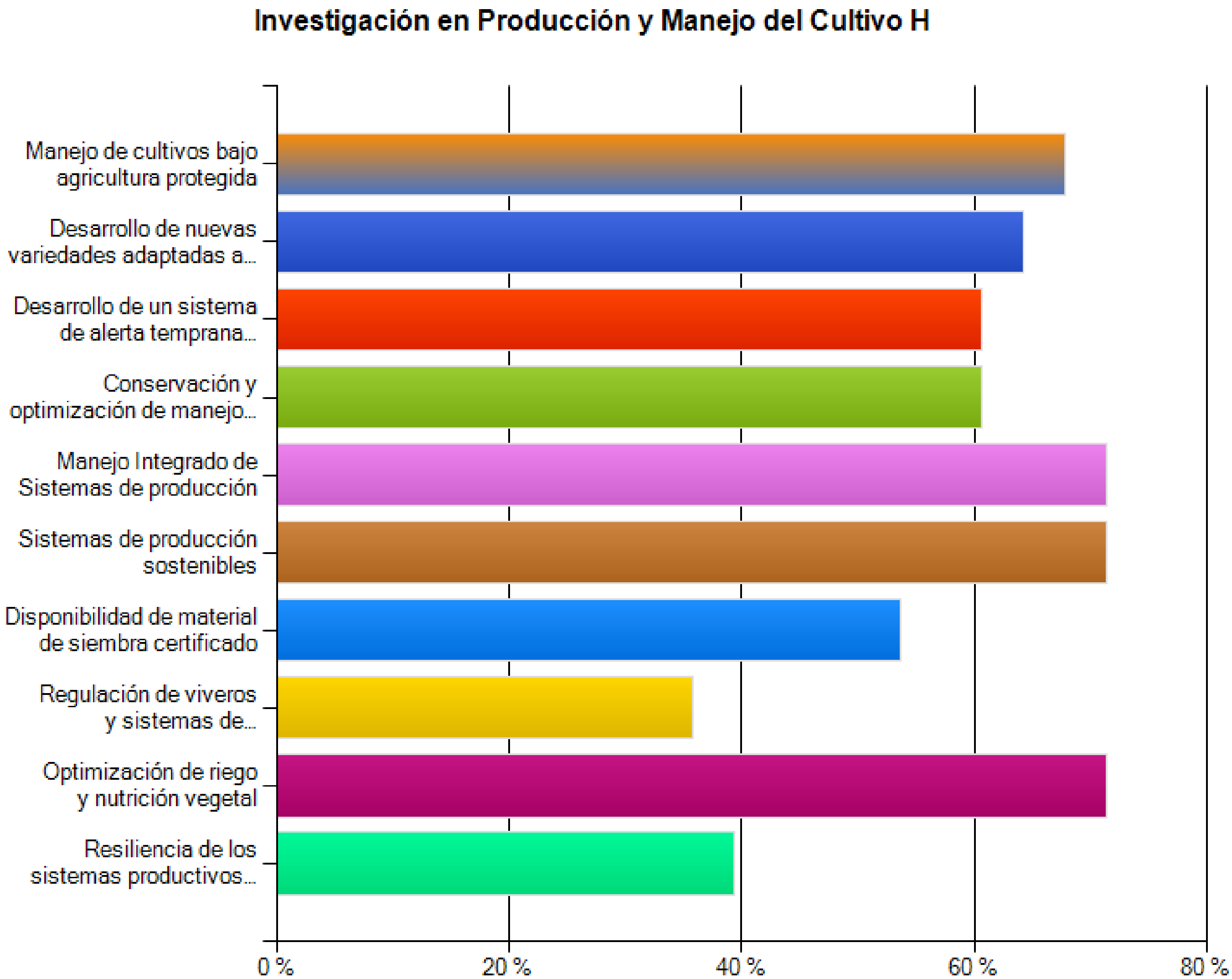
Q16 Both Countries



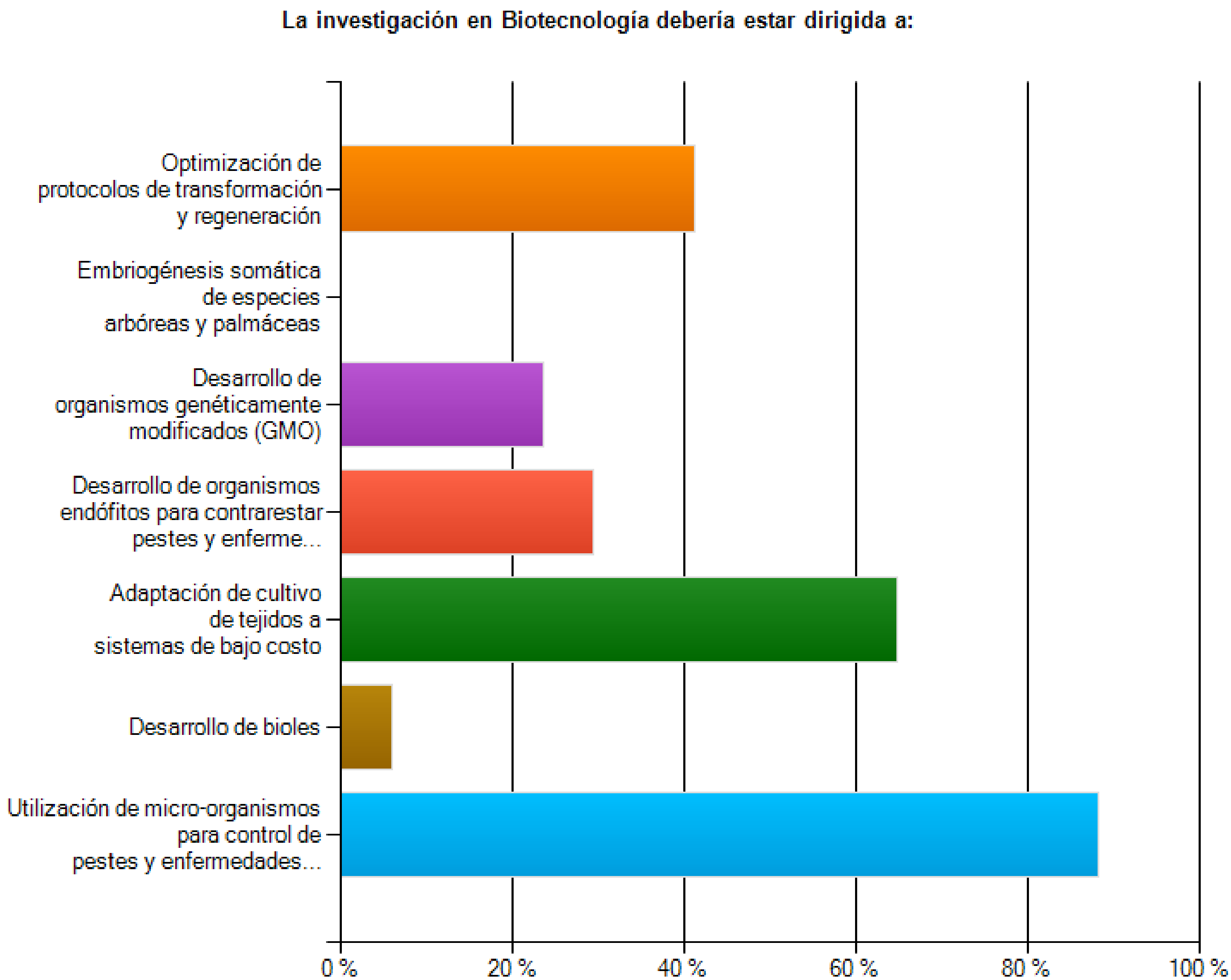
Q17 Guatemala



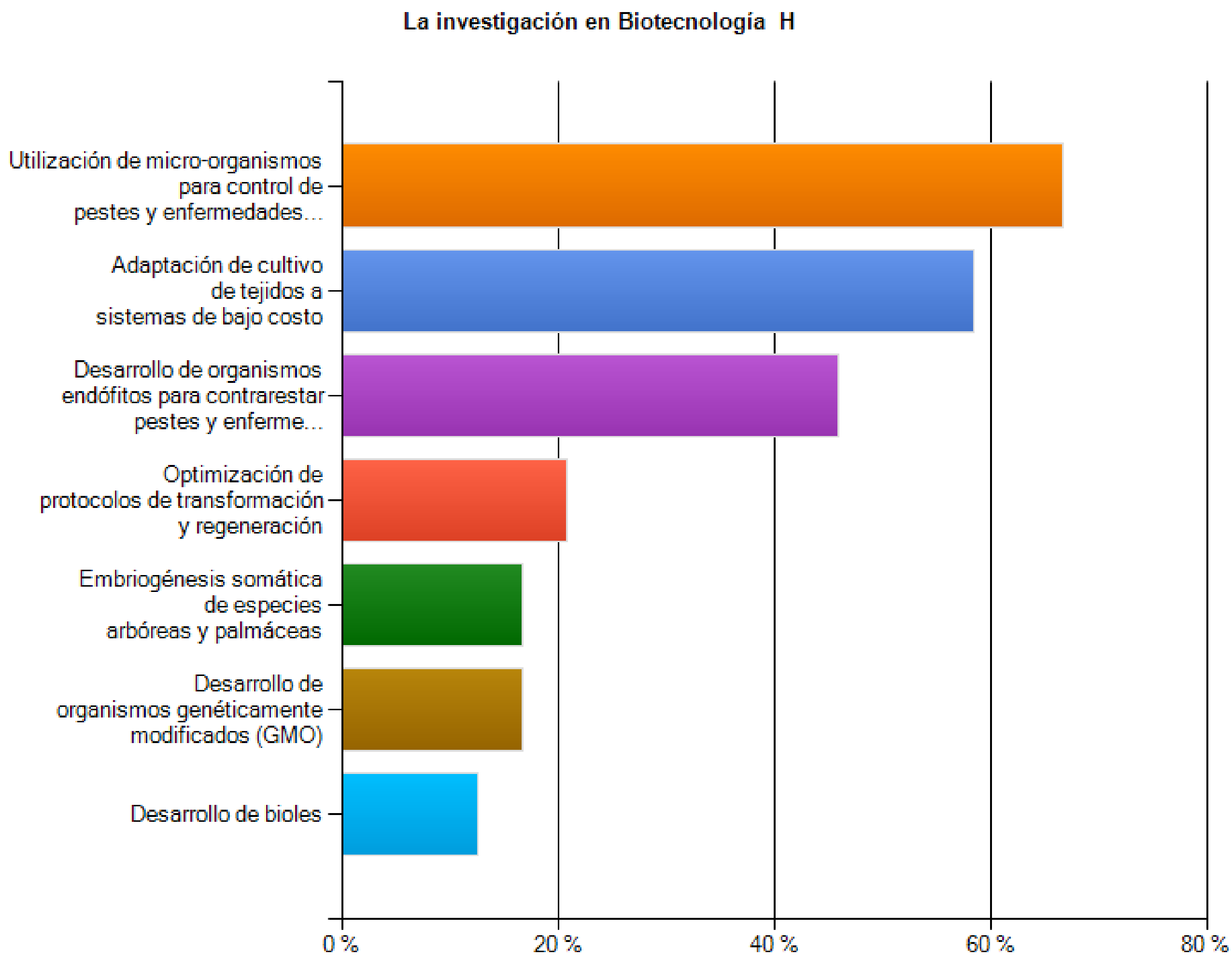
Q17 Honduras



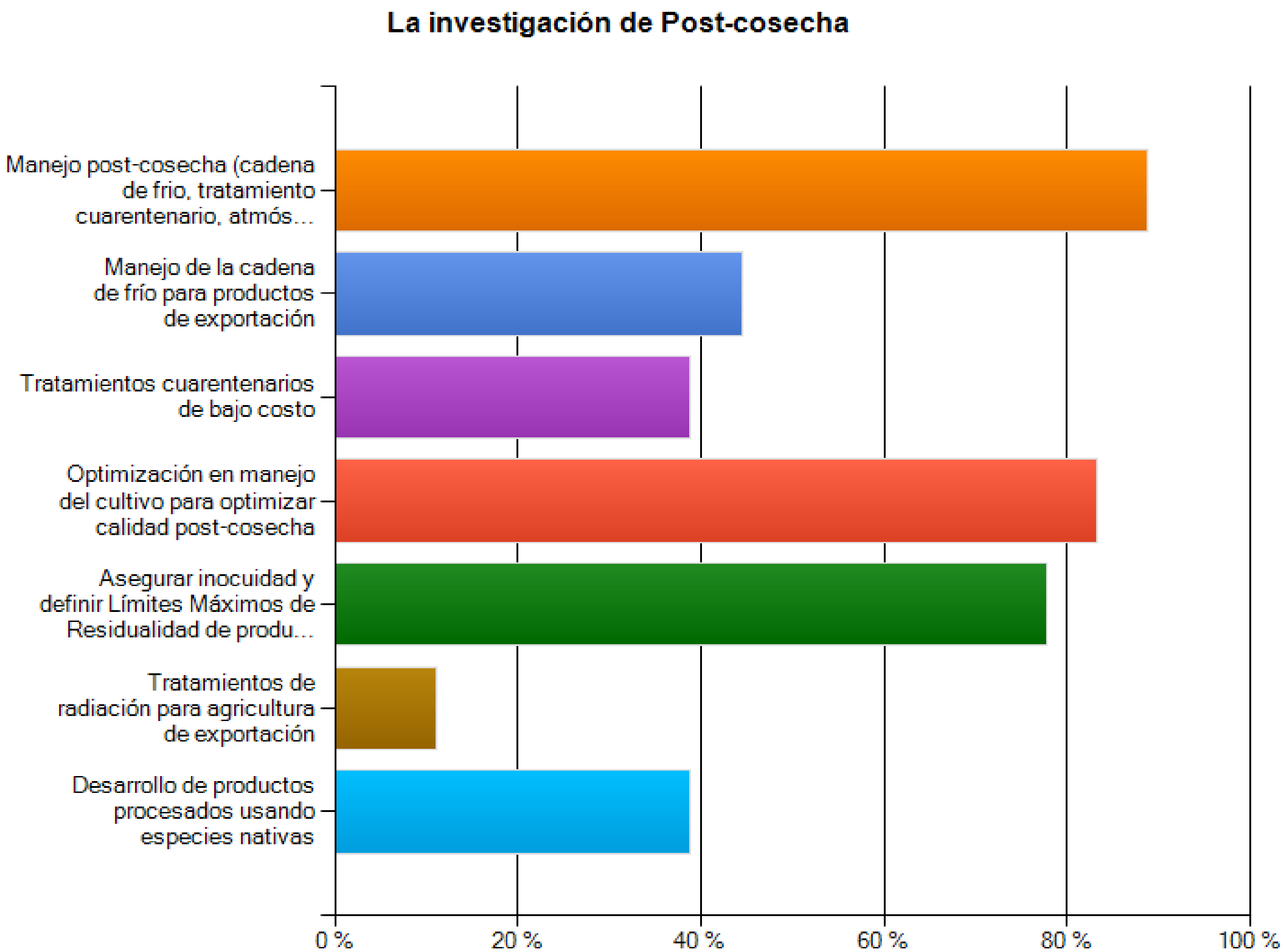
Q18 Guatemala



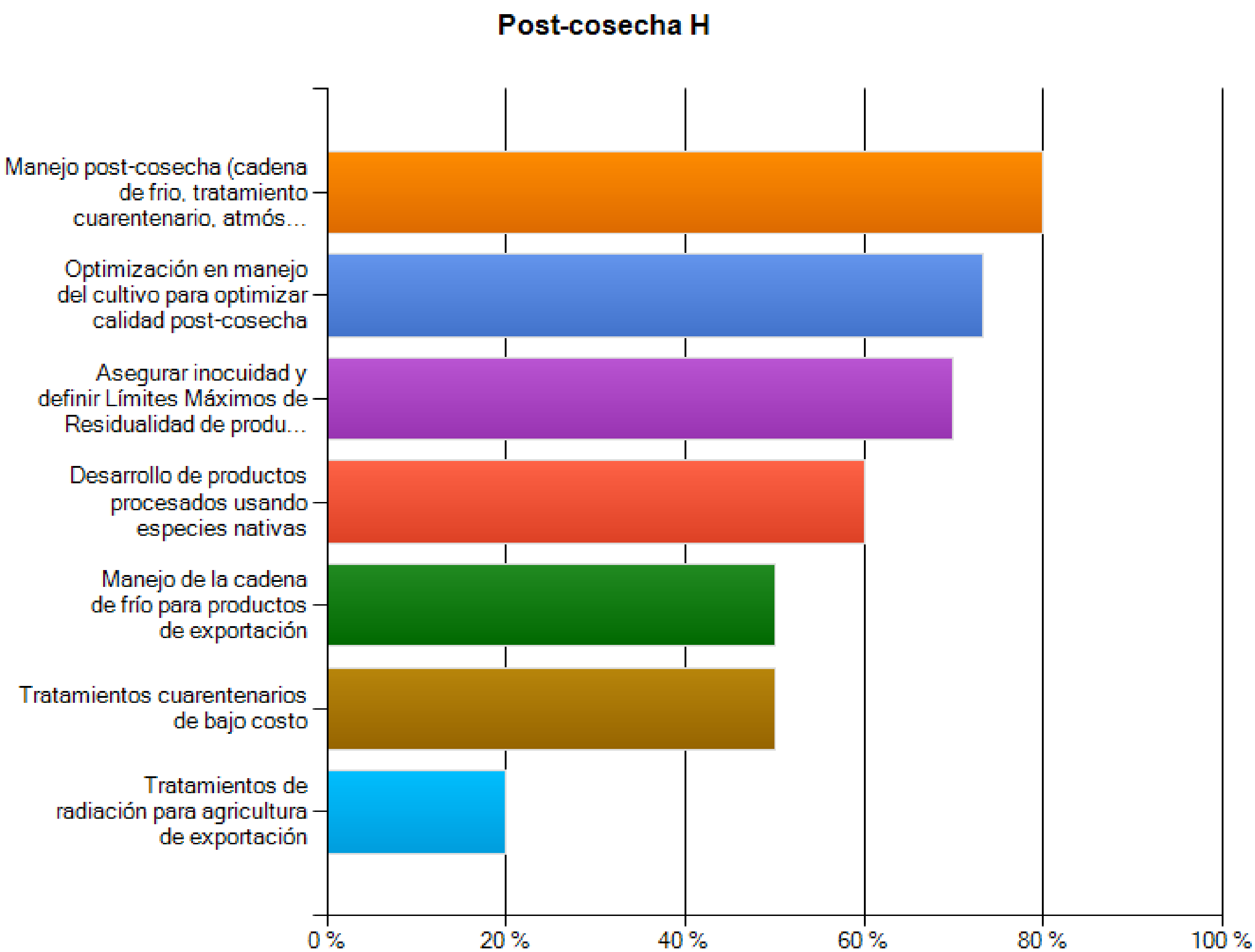
Q18 Honduras



Q19 Guatemala



Q19 Honduras



APPENDIX F: CROP-SPECIFIC RESEARCH NEEDS AS IDENTIFIED BY AGEXPORT, GUATEMALA

The export industry, with the support of AGExport, identified the sanitary and phytosanitary research needs for horticultural crops in Guatemala in 2012 (Agenda de Investigación e Innovación para atender problemas fitosanitarios y diseño de dos protocolos en el marco del Programa Integral de Protección Agrícola y Ambiental PIPAA). The analysis was conducted on two vegetables (tomato and snow peas), five fruits (avocado, Persian lemon, Andean berries (mora), mango, melon and rambutan; five ornamental types (foliage, cut flowers, stem and leaf cuttings, stems, orchids and other epiphytes), as well as in some differentiated products (cacao, coffee, honey, cardamom).

The needs were identified through interviews, survey and consultation with crop experts. Below, those problems encountered on crops relevant to the LAC Assessment report are presented.

VEGETABLES:

Snow Peas (*Pisum sativum*)

- *Fussarium oxysporum*
- Thrips (*Frankliniella* sp.) and leaf miner (*Lyriomiza huidobrensis*)
- Pesticide above MRL found in shipments to the United States and Europe
- Varieties susceptible to pests and diseases
- Trade concentrated mostly on United States (70%) and Europe (20%)
- Planting density is not appropriate and reduce productivity
- Nutrition is generic and do not consider crop phenology
- Irrigation recommendations are lacking
- Crop information

Tomato (*Lycopersicum esculentum*)

- *Clavibacter michiganensis* in seeds
- Thrips in greenhouses
- Bactericera (*Paratrioza*) cockerelli (Homoptera: *Psyllidae*)
- Tuta absoluta (Lepidoptera: *Gelichidae*)
- Producer organizations are needed

DIFFERENTIATED PRODUCTS:

Cardamom

- Lack of recommendations for fertilization
- Crops are based on a mix of varieties of low productivity
- Socio-economic information of communities involved is lacking
- GAPs and GMPs are not implemented by producers and processors. High risk for bacterial contamination
- Fruit drying is conducted on energy inefficient wood ovens. Increases pressure for deforestation and costs
- Shade management require tuning for Guatemala conditions

- Growers have almost no formal education and production is based on empirical practices. Producers are not organized and selling price sometimes drop below production costs.
- Diseases are starting to put pressure on crops

FRUITS:

Avocado (*Persea americana*)- Focus on variety Hass

- Lack of knowledge on prevalent pests in avocado
- Ovary fly, mites and Thrips
- Low productivity due to ringed peduncle
- Need to know water requirements of avocado trees
- Lack of suitable rootstocks (disease, drought, soil constraints)
- Industrial use of Criollo varieties is unknown
- Nutritional requirements are not clearly established in Guateamala
- Need to create certified nurseries that provide good genetic material to growers
- No access to standardized production manual for Hass in Guatemala

Citrus x latifolia (Tahiti lime)

- Management alternatives for : White mite (*Poliphagotharsonemus latus*) y Red mite (*Tetranychus urticae*); Fumagina (*Capnodium citri) / Aleurocanthus wlogumi*; Escales (Diaspididae); Citrus Tristeza Virus (CTV) and its vector *Toxoptera citricidus*
- Methods to improve fruit quality for exporting to Europe. Fruits are yellow-green and should be dark green
- Flowering control to cover months of high demand
- Training and Education (technical assistance and manuals)
- Certified nurseries
- Tactics to prepare for HLB

Mora (*Rubus glaucus*)

- Thrips main quarantine pest (90%)
- Use of non-permitted insecticides and fungicides (MRL)
- *Peronospora* sp and *Botrytis* sp affect fruits

Mango (*Mangifera indica*)

- Lack of GAP and HACC in farms and packing sheds
- Fruit fly free areas required with support of Moscamed
- Low mango productivity in Guatemala
- High variability in management practices and productivity.
- Effective mango flowering manipulation strategies
- Access to other varieties demanded by export markets

Melon (*Cuculis melo*)

- Soil sterilization based on Methyl Bromide will phase out in 2015. Need replacement alternatives.

- Rootstocks tolerant to fungi: *Monosporascus cannonballus*.
- Inoquity and GAPs to be implemented across the industry

Rambutan (*Nephelium lappaceum*)

- Tree canopy management to maximize yield
- Appropriate grafting technologies for rambutan
- Tree nutrition is not known
- Flowering control to extend production season and avoid competition
- Alternatives to deal with stem canker disease (*Dolabra nepheliae*)
- Varieties, chemical and biological methods to deal with Fungal diseases (*Phytophthora, Colletotrhicum, Oidium, Periconia, Capnodium*)
- Harvest and postharvest management alternatives to secure fruit quality
- Appropriate packing sheds and packaging
- Production manuals

ORNAMENTALS

Cut flowers

- Pruning techniques and protocols
- Pests and diseases (mites and thrips)

Foliage

- Weed control strategies
- Rooting is slow and costly
- Sporulation control in leather leaf to increase product quality
- Pests and diseases (mites and thrips)

Stem and leaf cuttings

- Technologies to induce multiple shooting
- Pests and diseases

Stems and canes

- Technologies to induce multiple shooting
- Pests and diseases

Orchids, epiphytes and others:

- Mass propagation technologies
- Weed control
- Pests and diseases

APPENDIX G: KEY RESEARCH AND EDUCATION PROGRAMS IN THE REGION

INSTITUTION	COUNTRY	RESEARCH	EDUCATION
Escuela Agrícola Panamericana, Zamorano	Honduras	x	x
Centro Agronómico Tropical de Investigación y Enseñanza, CATIE	Costa Rica	x	x
Escuela Agrícola Tropical del Trópico Húmedo, EARTH	Costa Rica	x	x
Universidad del Valle de Guatemala, UVG	Guatemala	x	x
Fundación Hondureña de Investigación Agrícola, FHIA	Honduras	x	

Appendix 6
Report from External Evaluation Team

FINAL REPORT

of the

External Evaluation Team of the Feed the Future Innovation Lab for Collaborative Research on Horticulture:

Award Number: EPP-A-00-09-00004

Prepared by External Evaluation Team Members

Errol W. Hewett
Michael A. Grusak
Subramanyam Shanmugasundaram (Team Leader)

June 20, 2013

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List of Acronyms

AA	Associate Awards
ADB	Asian Development Bank
APS	American Phytopathology Society
ALV	African Leafy Vegetables
AOTR	USAID Agreement Officer's Technical Representative
ASNAPP	Agribusiness in Sustainable Natural African Plant Products
ATRC	African Technical Research Center
AVRDC	The World Vegetable Center
AWARD	African Women in Agricultural Development
BARI	Bangladesh Agricultural Research Institute
BIFAD	Board for International Food and Agricultural Development
CABI	Centre for Agricultural Biosciences International
CA&ES	College of Agriculture and Environmental Sciences
CARE	Cooperation for Assistance and Relief Everywhere
CEAPRED	Center for Environmental and Agricultural Policy Research, Extension and Development
CGIAR	Consultative Group on International Agriculture
CIAT	Centro Internacional Centro de Agricultura Tropical
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
COL	Commonwealth of Learning
CB	Commercial Bank
CNP	Continuation Project
CP	Comprehensive Project
DAI	Development Alternatives International
ECHO	Educational Concern for Hunger Organization
EET	External Evaluation Team
EM	Effective Microorganism
EMINA	Effective Microorganism from Institute of Agrobiology
EP	Exploratory Project
FAO	Food and Agricultural Organization
FFS	Farmer Field School
FHIA	Fundacion Hondurena de Investigacion Agricola
FPEAK	Fresh Produce Exporters Association of Kenya
GAP	Good Agricultural Practices
GHA	Global Horticultural Assessment
GHI	Global Horticulture Initiative
HARE	Horticulture Action Research and Education Network
HC	Host Country
HCA	Horticulture Council of Africa
Hort CRSP	Horticulture Collaborative Research Support Program
HUA	Hanoi University of Agriculture
IAB	International Advisory Board
ICT	Information and Communication Technology

IDE	International Development Enterprise
IFAD	International Fund for Agricultural Development
IIP	Immediate Impact Projects
IMW	Information management Workshop
ISHS	International Society for Horticulture
KARI	Kenya Agricultural Research Institute
KU	Kasetsart University
LAC	Latin America and Caribbean Region
LAPDN	Latin American *Phytophthora* Diagnostic Network
MDGs	Millennium Development Goals
ME	Management Entity
MRL	Maximum Residue Levels
NARC	National Agricultural Research Institute
NGO	Non-Government Organization
ODA	Department for International Development, UK
OFSP	Other Food Security Programs
PI	Principal Investigator
PP	Pilot Project
PTSC	Postharvest Training and Service Center
RFA	Request for Application
RMIT	Royal Melbourne Institute of Technology
RUA	Royal University of Agriculture, Cambodia
SANREM	Sustainable Agricultural, Natural Resources and Environment management
SLM	Savings Led Microfinance
UNDP	United Nations Development Program
USAID	United States Agency for International Development

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Executive Summary

High-value horticultural crops can improve the income and health of smallholder households. Horticulture can be an avenue of empowerment for women, who often provide the labor, but frequently without pay. Women are critical to many parts of the horticultural value chain, from labor, to marketing, to value-added processing, to nutrition security at the household level. Horticultural crops are labor- and knowledge-intensive, but can provide dietary diversity if eaten, increased incomes if sold, and higher, diversified profits if processed. The opportunities for women in horticulture are not because they are labor intensive but because they are nutritious and high value, generating income for women farmers as well as men, and can be value added. Vegetables and fruit are rich in micronutrients and help in diet diversification and alleviation of nutritional deficiencies, especially in children and women. Horticultural crops are highly perishable, so postharvest losses can be very high and production is very risky. Investment in research and development of horticulture lags behind that of staple cereals and legumes. Recognizing the importance of horticulture for food security and alleviation of hunger, USAID funded the University of California, Davis, AVRDC, Michigan State University and University of Hawaii at Manoa to organize a series of consultations at University of California, Davis, Africa, Latin America and the Caribbean, and Asia and the Near East to conduct an intense in-depth analysis of opportunities and challenges for global horticultural development. The resulting Global Horticultural Assessment (GHA) made a number of important recommendations. The Horticulture Collaborative Research Support Program (Horticulture CRSP, hereafter referred to as the Horticulture Innovation Lab, was the response of the U.S. Government to the GHA. Implementation and management of Horticulture Innovation Lab was awarded to University of California, Davis and its partners, Cornell University, University of Hawaii at Manoa and North Carolina State University in October 2009. University of California, Davis organized a management team (ME).

The major themes of Horticulture Innovation Lab are:

- Information accessibility;
- Capacity building;
- Technological Innovation;
- Gender equity.

The objectives of Horticulture Innovation lab are:

- Apply “leapfrog” technologies to increase smallholder participation in markets;
- Build local scientific and technological capacity;
- Facilitate the development of policies that improve horticultural trade;

To accomplish these objectives the Horticulture Innovation Lab introduced the following types of projects:

- Immediate Impact Projects (IIPs-$150,000 for one year)
- Exploratory Project (EP-$75,000 for one year)
- Pilot Project (PP-$500,000 for three years)
- Continuation Project (CNP-$250,000 for two to three years)
- Comprehensive Projects (CP-$1,000,000 for three years)
- Focus Projects (FP-$100,000 for one to two years)

- Associate Awards (from Missions and CGIAR centers)

A three-member external evaluation team (EET) was commissioned in March 2013 to provide USAID and the ME with constructive feedback on the past research performance and management of Horticulture Innovation Lab. This report constitutes the extensive efforts of the EET to obtain relevant information through an in-depth review of documents, surveys, personal contacts and site visits to evaluate the Horticulture Innovation Lab program. Two members of the EET were able to visit University of California, Davis and meet with the ME and some PIs, and to visit field sites in Cambodia, Vietnam and Thailand, and the USAID Mission in Cambodia. All three members had the unique opportunity to participate in the annual meeting of the Horticulture Innovation Lab in Nairobi, Kenya and were able to meet and discuss with a large cross section of US PIs, host country PIs, collaborators, NGOs, public and private sector stakeholders, and the International Advisory Board Members (IAB) of Horticulture Innovation Lab. A survey of the host country representatives was conducted, and the results were used in the evaluation.

The EET commends the ME for their leadership in developing an open and transparent review process for selecting the projects and for efficiently managing them. Previous Director Dr. Ron Voss, current Director Dr. Elizabeth Mitcham and the Associate Director, Ms. Amanda Crump, are doing an excellent job in efficiently reviewing the projects, following work plans, evaluating research progress and attracting new partners to the program. The EET admires the Program Council in the past and currently the IAB, which were effective in providing guidance and advice to lead the ME in the right direction on programmatic and fiscal matters of the Horticulture Innovation Lab.

Within the short span of three years the Horticulture Innovation Lab has made significant progress on many fronts. They have:

- Approved 15 IIPs involving 9 US universities and 20 host countries;
- Approved 10 EPs involving 8 US universities and 18 host countries;
- Approved 9 PPs involving 3 US universities and 14 host countries;
- Approved 7 CNPs involving 7 US universities and 9 host countries;
- Approved 2 CPs involving 2 US universities and 3 host countries;
- Approved 1 FP involving 1 US university and worldwide hosts;
- Approved 25 six-months to one year Trellis Fund Projects.

Within the first two years of its existence, the Horticulture Innovation Lab became widely recognized as a valuable horticultural research and development advocate through its IIPs and EPs. The major accomplishments of Horticulture Innovation Lab as of May 2013 can be summarized as follows:

- Established collaboration with 18 US universities and 200 organizations worldwide;
- Number of new technologies under research: 100;
- Improved management implemented: 10,000ha;
- Number of households reached: 4,935;
- Number of students involved in projects: 108;
- Total number of people trained: 18,297;

- Percent of farmers/trainers who were women: 51.

In addition to the above, Horticulture Innovation lab has established Regional Center of Innovation (s) (Hereafter will be referred as Center (s)) at Kasetsart University in Bangkok, Thailand, at Zamorano University in Honduras and recently with the Kenyan Agricultural Research Institute [KARI] and the Fresh Produce Exporters Association of Kenya [FPEAK] at Thika, Kenya. The Horticulture Innovation Lab has also established a Postharvest Training and Services Center (PTSC) at AVRDC, Arusha, Tanzania.

Some of the selected specific outputs from projects to date include:

- Selection of improved virus resistant tomato and chili cultivars for Central America;
- Use of drying beads for improved seed storage;
- Promoting EMINA as a bio-fertilizer and a bio-pesticide for safe vegetable production;
- Training women entrepreneurs for producing and marketing EMINA and grafted seedlings;
- Development and use of diagnostic tools for the identification of *Phytophthora* in vegetable crops;
- Testing low-cost pest exclusion nets for safe vegetable production;
- Better understanding of the management, production, marketing and use of nutritious African Indigenous Vegetables;
- Development and use of concentrated solar drying of mango and tomato;
- Evaluating and use of CoolBot technology to preserve the postharvest quality of vegetables;
- Training and use of grafting in tomato and chilies to overcome soil-borne diseases.

An impressive accomplishment achieved through PTSC was that 36 trainers from the initial training trained 8,378 people in their countries and they in turn have trained 12,338 farmers.

The EET found that project monitoring and evaluation was carefully and methodically done by the Associate Director, Ms. Amanda Crump, and an external consultant, Dr. Paul Marcotte. Those projects that lagged behind or could not deliver were given sufficient time to catch up. So far, only one project has been cancelled since it could not move. In that case, the PI's institution had limitations related to contracting that hindered progress. It is too early to assess the impacts of many of the projects. Many projects have undertaken built-in baseline surveys, the outputs of which can be used for comparisons with final outcomes.

The ME manages the financial aspects of Horticulture Innovation Lab with the University of California, Davis Department of Plant Sciences Financial Division staff. The two staffers, Ms. Heather Kawakami and Ms. Sabrina Morgan, are doing an excellent job and should be congratulated for effectively managing the funds and addressing all of the issues that arise from the PIs and the host country institutions. They are very efficient, considering the government and university budget and accounting requirements.

The information, communication and technology dissemination unit has used a variety of means to reach clientele of Horticulture Innovation Lab. They have developed several useful tools such as the Global Horticulture Knowledge Bank and a map of horticultural projects worldwide .

Considering the short time that the Horticulture Innovation Lab has been in existence, it has been very successful in making its presence known to the international scientific community. The Horticulture Innovation Lab has made serious endeavors to disseminate outputs from their program as widely as possible. The home site of the Horticulture Innovation Lab lists a wide range of information sources and types that are freely available.

The ME should be congratulated for its efforts to engage with the Missions in host countries. The EET strongly recommends that the ME continue to pursue engagement with the Missions and to possibly inform and involve Missions in the project review process. The ME also should encourage the PIs and the host country representatives to periodically meet with Missions so that they can be informed of significant outputs and can appraise the progress of the project.

The EET recommends that the ME Information Management and Communications team develop processes to enable more rapid communication of potentially successful ideas and technologies being developed in one part of the world to be communicated quickly to other PIs in different countries for evaluation and incorporation into their projects. (For example, the biological management practices using EMINA in Vietnam have application in Cambodia, Africa and Central America).

The Regional Centers of Innovation in the three different regions are high profile investments of the Horticulture Innovation Lab and they serve as research and development hubs. Although the seed money given to Regional Centers of Innovation was modest for the first phase, the EET strongly recommends that funds for the Regional Centers of Innovation be increased in the second phase.

The Director and the Associate Director spend only 50% and 75% of their time respectively for Horticulture Innovation Lab. The Director has the full responsibility of leading, administering, and decision-making, and this includes considerable domestic and international travel. Establishment of Regional Centers of Innovation adds an additional responsibility. Meeting Missions and other public and private donor agencies for fundraising is a major responsibility. Considering all of these responsibilities, the EET strongly recommends that the Director position be made full time for the second five-year phase.

The Horticulture Innovation Lab has achieved the objectives set out in the original proposal to USAID. Horticulture Innovation Lab responded with alacrity to the changes that were foisted upon them following strategic and policy changes implemented by USAID 15 months into their current tenure of the program; they demonstrated flexibility, initiative and good sense in adapting rapidly to the new guidelines to Feed the Future directions and have continued to meet deadlines and milestones. Therefore, the EET, without reservation, recommends that the Horticulture Innovation Lab be renewed for the second five-year term, and University of California, Davis should continue to be the ME for Horticulture Innovation Lab.

Recommendations

Recommendation 1. The EET recommends that the ME carefully consider recruiting clearly accomplished people from different horticulture specialty areas from both the public and private sector as members of IAB with no conflicts of interest.

Recommendation 2. The EET strongly recommends that the ME review the results of the survey of host country PIs in setting the research priorities and developing the future research agenda.

Recommendation 3. The ME should be congratulated for its efforts to engage with the Missions in host countries. The EET strongly recommends that the ME proactively continue the engagement with the Missions and where it is possible, inform and involve the Mission in the project review process (as requested in Cambodia) so that they feel that they have an obligation and ownership for the project. The ME also should encourage the PIs and the host country representatives to periodically meet with the Mission and apprise them of the progress of the project and showcase the significant outputs. More direct integration of Horticulture Innovation Lab research into Mission value chain projects is needed.

Recommendation 4. The EET recommends that the ME regularly invite public and private donor agencies such as FAO, World Bank, IFAD, CGIAR, Gates Foundation, and NGOs to participate in their workshops and annual meetings. In addition, the ME should regularly distribute their publications, press releases and significant findings to the above agencies so that they are aware of the accomplishments of the Horticulture Innovation Lab.

Recommendation 5. The EET recommends that the USAID AOR serve as an intermediary between the ME and the Missions so that it can facilitate collaboration between the Horticulture Innovation Lab and the Missions.

Recommendation 6. We recommend that training efforts and appropriate workshops are built in as an integral component of most, if not all future projects, as this will facilitate both implementation and capacity building objectives.

Recommendation 7. The EET recommends that the Horticulture Innovation Lab, in conjunction with in-country collaborators, extend the postharvest training program, so successful in Tanzania, into other Feed the Future countries using the Regional Centers of Innovation as a base, and that the Regional Centers of Innovation be equipped appropriately to enable this to occur.

Recommendation 8. The EET recommends that the ME Information Management and Communications team and in particular the new communications coordinator work assiduously to develop close links with news editors in all branches of the media in order to create better opportunities for wider distribution of interesting, good news and successful stories flowing from Horticulture Innovation Lab activities. Such stories are fine to have at a local level, but they need to find places in national and international outlets.

Recommendation 9. The EET recommends that the ME Information Management and Communications team further develop social media systems for communicating messages of hope and success about the role of horticulture in reducing poverty, increasing food security, improving health and nutrition of women and children, increasing household incomes, and producing safer food and vegetables for household and market consumption.

Recommendation 10. The EET recommends that the ME Information Management and Communications team establish links with the Commonwealth of Learning to determine the processes and protocols that they are using to help smallholder farmers gain knowledge of technologies, management and markets using modern ICT technologies and determine if there is any opportunity for collaborating in selected past and present British Commonwealth countries.

Recommendation 11. The EET recommends that the current protocols and practices undertaken by the ME to ensure gender equity and inclusion on all Horticulture Innovation Lab projects be commended and that efforts be maintained to ensure that a person with expertise and experience in social sciences (such as sociology, anthropology) be included in all future project teams where practicable and on a need basis.

Recommendation 12. The EET recommends that the Horticulture Innovation Lab be renewed and continued for another five-year phase and that the ME remains at University of California, Davis for the second phase with a non-competitive renewal.

Findings and Conclusions

I. Introduction

Currently there are 870 million people in the world suffering from chronic hunger. Nearly 3.5 million children die each year due to under- and malnutrition. The world population is expected to increase to more than 9 billion by the year 2050. To feed the world, food production needs to be increased by 60%. About one-third of the children younger than five years in low-income countries are stunted and almost half of all children and women in low-income countries are anemic indicating the significance of micronutrient deficiency problems in these countries (USAID, March 3, 2013 presentation in Tanzania). In developing regions of the world, an estimated 3 billion people survive on less than US$2 per day (GHA, 2005).

Justifiably, major effort is placed and a large amount of funding is provided to support the research and development of cereals and food legumes. This will definitely address the calorie and protein needs of people in developing countries. Horticulture has been neglected for quite some time. Horticultural research and development efforts are on the decline in most of the US universities as well as educational institutions around the world. USAID's investment in horticulture crop centers between 1968 and 1996 was less than one tenth of the amount invested for staple cereal crop centers (GHA, 2005). Due to their high economic and nutritive value, horticultural crops are valuable instruments for agricultural development. Specifically for smallholder farmers, horticulture serves as an engine for agricultural and economic diversification focusing production on local, regional and international markets. Fruit and vegetable farmers in India generate five to eight times more profit than cereal farmers. In Kenya, the farmers who grow fruits, vegetables and flowers can earn six to twenty times more than maize farmers (GHA, 2005). However, the constraints to horticultural crop production, processing, marketing and consumption along the value chain are numerous and they need to be addressed to bring resolution and to help the smallholder farmers.

Vegetable and fruit consumption in the developing countries in Africa, South and SE Asia, and Central America is very low (only 30 to 40 Kg/caput/year). Farmers have difficulty in getting improved, locally adapted vegetable varieties and good quality stocks of fruit plants. Access to good quality seeds of vegetables is also a major bottleneck for vegetable production. Pests and diseases force the farmers to be at the mercy of pesticide traders, which results in vegetables with high pesticide residue. Postharvest losses due to poor handling, lack of infrastructure, poor transport and lack of knowledge on proper packaging causes losses of up to 40%. Investment in understanding the problems of vegetable and fruit production and the value chain will enable researchers to creatively resolve the issues through location specific research. The outputs of these research and follow-up development activities will vastly improve the production of quality vegetables and fruits, improve the income of the rural poor, and help alleviate the micronutrient malnutrition among young children and women in the developing countries. Invariably, women are involved in vegetable production and marketing. Linking the vegetable producers to market will empower women to become successful entrepreneurs.

Recognizing the importance of diet diversification, micronutrients in nutrition, enhancing job opportunities especially for women, and improving income of smallholder farmers USAID funded University of California, Davis, The AVRDC (World Vegetable Center), and a consortium of US Universities (Michigan State University, Purdue University, and University of Hawaii at Manoa) in September 2004 to conduct a series of consultations at University of California, Davis and three strategic regions around the world in Africa, Latin America and the Caribbean, and Asia and the Near-East to have an in-depth analysis of the opportunities and challenges for global horticultural development. The resulting output, the Global Horticultural Assessment (GHA, 2005) was a document emphasizing the need to increase horticultural research to alleviate poverty, hunger and nutrition in developing countries. It also came up with a list of priority research areas, crops and capacity building recommendations in horticulture. Full details of the Global Horticulture Assessment can be found in the following International Society for Horticultural Science publication: Scripta Horticulturae Number 3, pp. 134, 2005 and is available on-line at
http://www.ishs.org/scripta-horticulturae/global-horticulture-assessment.

Based on the recommendations of the GHA, USAID decided to organize a Horticulture Collaborative Research Support Program (Hort CRSP). Of the proposals received from various institutions desiring to host the Horticulture CRSP, the one from University of California, Davis was accepted by USAID. Leader with Associates Cooperative Agreement for Hort CRSP was awarded to University of California, Davis as the Management Entity (ME) from October 2009 to September 2014 with a budget of US$15 million. As per the Feed the Future Food Security Initiative of the President Obama administration, the CRSPs have been renamed as Innovation Labs. Currently there are ten Feed the Future Innovation Labs supported by USAID. The Hort CRSP was renamed accordingly as (hereafter referred to as Horticulture Innovation Lab). Horticulture Innovation Lab is currently in its fourth year.

The USAID has organized a three-member External Evaluation Team (EET, See Appendix 1) to assess the program management, research performance to date and to provide USAID and the ME with constructive feedback on the above areas with a forward looking view. The EET should also provide recommendations based on their review, whether a second final five-year phase should be awarded. If the answer is yes then the EET should provide suggestions on the research and development focus for the second final five-year phase. The scope of work of EET is given in Appendix 2.

The EET report is based on:

1. Extensive review of documents provided by USAID, ME and documents obtained from the Internet (see list of documents in Appendix 6).
2. Conference calls EET had with the USAID team managing the Horticulture Innovation Lab, the ME and telephone conversations with ME, PIs and other stakeholders involved with Horticulture Innovation Lab.

3. Discussions with the International Advisory Board Members of Horticulture Innovation Lab (IAB).
4. The result of a survey of host country investigators arranged by Dr. Timothy Dalton of Kansas State University in consultation with the EET members (Appendix 3).
5. Visit of two EET members, Errol Hewett and S. Shanmugasundaram, to University of California, Davis and their discussion with the ME and a number of PIs.
6. Field visits of two EET members, Errol Hewett and S. Shanmugasundaram, to Cambodia, Vietnam, and Thailand.
7. Field visits of all three EET members to Tanzania and Kenya. The EET participated in the Annual Meeting of the Horticulture Innovation Lab organized at the Safari Park Hotel in Nairobi, Kenya, which provided an opportunity for the EET to interact face-to-face with the PIs, host country representatives, ME and the IAB. This helped the EET to create this report constructively.

The EET has organized the report as follows:

- Introduction
- Horticulture Innovation Lab Organization, Structure and Function
- Management of Horticulture Innovation Lab
- Research Program Focus and Output
- Alignment with Feed the Future priorities
- Human and Institutional Capacity Building
- Collaboration Outreach and Institution Building
- Gender Inclusion
- Monitoring and Evaluation
- Research and Development Focus of a Second, Final Five-Year Phase, if awarded

The USAID suggested format in the Scope of Work for the EET was closely followed in the preparation of this report.

II. Horticulture Innovation Lab

1. Horticulture Innovation Lab Organization, Structure and Function of the Management Entity

Inception of the Horticulture CRSP.
The implementation of the Horticulture CRSP was awarded to University of California, Davis and its partners, Cornell University, University of Hawaii at Manoa and North Carolina State University. In response to the question: "How were these three partners chosen?" it was indicated that these three partners had the appropriate expertise in horticulture. Although University of Florida and Texas A&M University were also considered, they were not included since they were preparing their own proposals for Horticulture CRSP. The ME may reconsider these partners for the second phase. The Horticulture CRSP is housed in the Department of Plant Sciences in the College of Agricultural and Environmental Sciences (CA&ES) and managed by a team, which will be

referred to as the Management Entity (ME). The CA&ES International Programs Office also provides support and guidance for Horticulture CRSP. The following individuals were the initial ME at University of California, Davis:

Dr. Ron Voss, Director
Dr. Elizabeth Mitcham, Associate Director
Dr. Mark Bell, Communication and Learning
Dr. Michael Reid, Innovation and Special Projects
Ms. Amanda Crump, Project Representative
Mr. Peter Shapland, Student
Ms. Diana Puccetti, Office Administrative Assistant
Ms. Heather Kawakami, Budget and Finance
Ms. Sabrina Morgan, Budget and Finance.

The Agreement Officer and Technical Representative of the USAID was Dr. Larry Paulson from 2010-2011. Dr. Jim Yazman and Dr. John Bowman replaced Dr. Larry Paulson for 2011-2012. Dr. John Bowman and Dr. Saharah Moon Chapotin succeeded Dr. Jim Yazman in 2012.

Current ME organization and responsibilities.

Dr. Ron Voss retired as the Director of Horticulture CRSP at the end of 2011. The current ME of the Horticulture Innovation Lab since 2012 is:

Dr. Elizabeth Mitcham, Director
Ms. Amanda Crump, Associate Director
Ms. Heather Kawakami, Business Unit Manager (Budget and Finance)
Ms. Sabrina Morgan, Account Manager (Budget and Finance)
Dr. Mark A. Bell, Leader Communications and Information Transfer
Dr. Michael S. Reid, Leader Innovative Technologies and Special Projects
Ms. Britta Lilley Hansen, Regional Centers of Innovation Specialist
Ms. Brenda Dawson, Communications Coordinator
Ms. Diana Puccetti, Office and Event Planning Assistant
Dr. Paul Marcotte, External Monitoring and Evaluation Consultant
Ms. Elana Peach-Fine, Graduate Assistant
Ms. Kelsey Barale, Graduate Student Intern
Ms. Azia Hasan, Student Assistant

The ME is an institution with legal status of a judicial body. The ME administers the Cooperative Agreement from USAID and manages the Horticulture Innovation Lab and all its activities, including collaborative research, education, and outreach programs. The ME has clear and well-defined responsibilities. The structure of Horticulture CRSP is presented in Fig. 1.

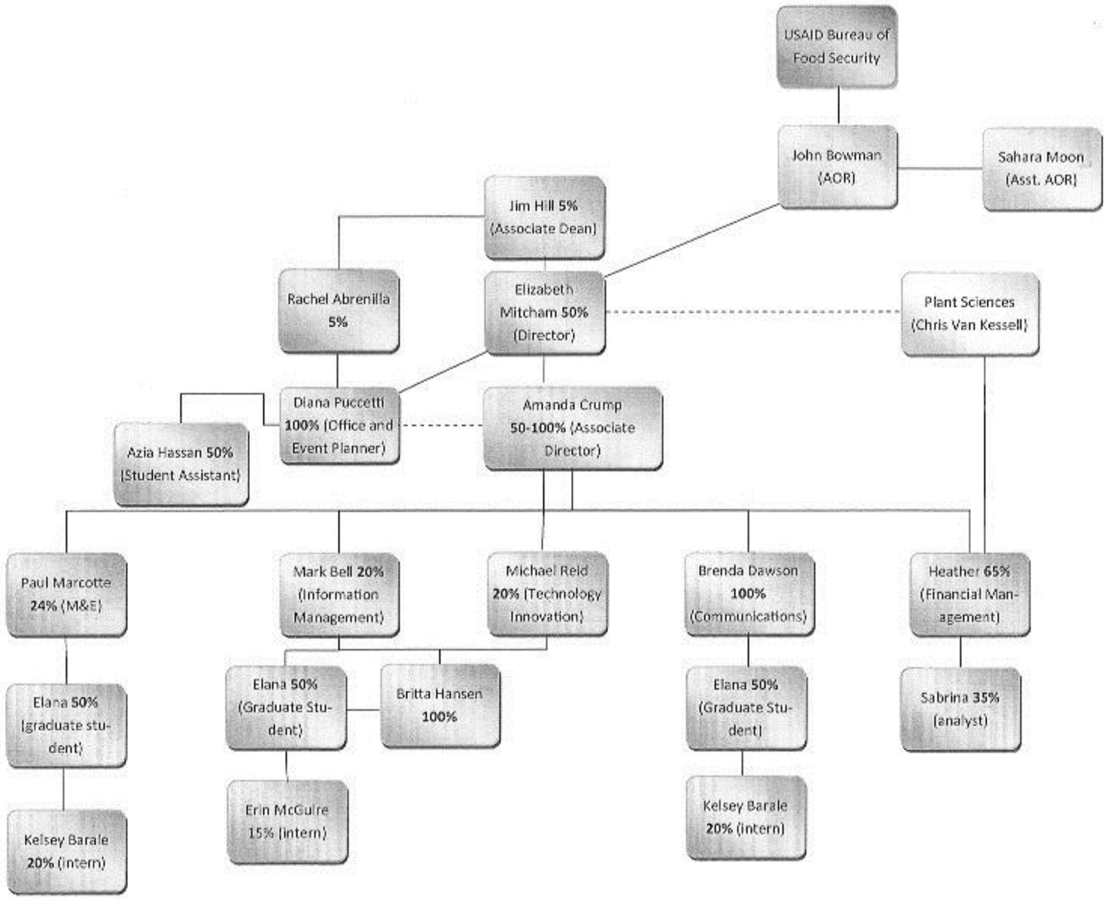
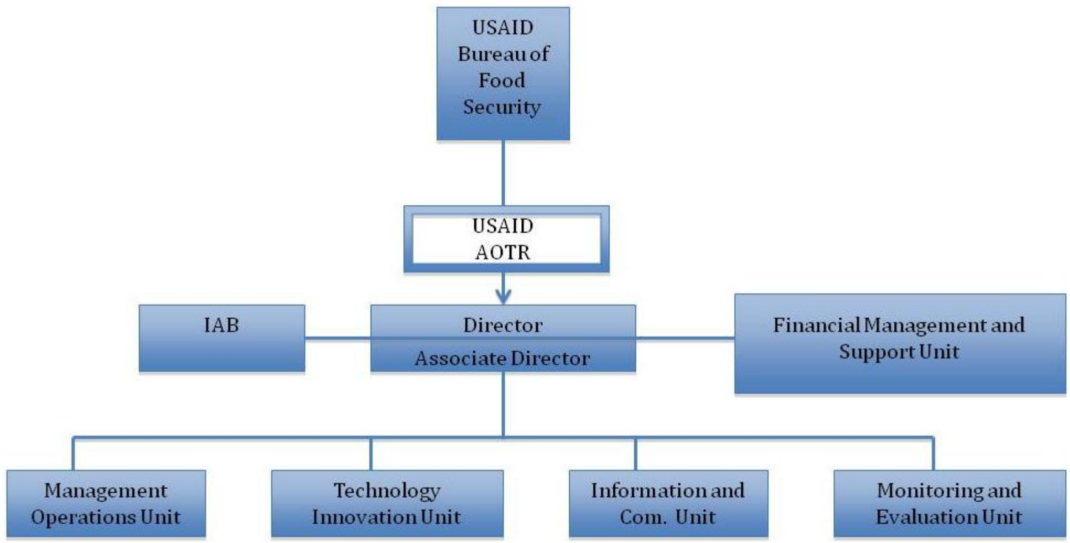


Fig.1. The Management Entity structure of Hort CRSP

The organizational structure of Horticulture Innovation Lab combines both the structure and personnel. Some of the personnel have multiple responsibilities. For example, Associate Director Ms. Amanda Crump has 75% responsibility tor Horticultural Innovation Lab (although in the chart it is mentioned as 50-100%) and the rest includes teaching at the University, Ph.D. preparation for herself among other things. Therefore, it is rather confusing, and it is difficult to understand the different entities and the chain of command. A simple organizational structure can explain the clear line of authority and chain of command. Names can be inserted in each of the categories and they may change from time to time for various reasons. The EET therefore, suggests the following organizational structure, which can be modified as necessary:

Fig. 2. Suggested Organizational Structure of Horticulture Innovation Lab



The ME in consultation with USAID and the IAB plans strategic directions, defines general priorities, sets the agenda, initiates processes and systems to accomplish the priorities, allocates resources, convenes meetings and planning sessions and workshops, and modifies directions based on advice and evaluations from the IAB and USAID. It also vigorously mobilizes partners and seeks additional resources from various public and private sources. Since University of California, Davis houses and hosts Horticulture Innovation Lab, the Chancellor, Dean of the CA&ES, Associate Dean of International Programs and the Chair of the Department of Plant Sciences of University of California, Davis provide logistic support for Horticulture Innovation Lab.

The Management Operations Unit include:
- Associate Director
- Communications Coordinator
- Regional Centers of Innovation Specialist
- Graduate Student and Research Intern

The Financial Management and Support Unit include a Business Unit Manager and an Account Manager from the University of California, Davis Plant Sciences Division, and both of them are financial analysts. In addition, the Events and Office Management Assistant is also included in this unit. They are directly under the Director. The Financial Management and Support Unit provides logistical backup such as accounting, financial management, daily official chores, and events planning.

For Horticulture Innovation Lab, University of California, Davis provides an array of support functions, in addition to financial management, information systems, computer support, personnel funding, and management of awards and sub-awards, travel and sponsored programs.

A Technology Specialist and an Information and Communication Specialist lead the Technology and Information and Communications Units, respectively.

Currently, the Monitoring and Evaluation Unit utilizes the Associate Director for internal evaluation. An External Evaluator provides unbiased oversight for monitoring and evaluation.

With the foregoing descriptions, the chain of command is clear, and the responsibilities are well defined with a compact structure. The names of the people can be provided for each unit.

During the first year, the Horticulture CRSP ME organized a Program Council consisting of nine members from University of California, Davis (four of whom are from the ME serving as ex-officio members) and one each from the other three partner institutions, namely North Carolina State University, University of Hawaii at Manoa and Cornell University to guide the activities of the Horticulture CRSP. Selection of members was based on their horticultural and international experience. Members of the Program Council had three major responsibilities:

1. Select and recommend the appropriate Immediate Impact Projects [IIPs];
2. Offer counsel to the Director on technical and management issues related to the implementation of IIPs;
3. Select and appoint members of an International Advisory Board to replace the Program Council. To ensure continuity, it was envisioned that four members of the Program Council would continue as Advisory Board members.

The members of the Program Council were:

Dr. Elizabeth Mitcham, University of California, Davis, Chair
Dr. Ron Voss, University of California, Davis
Dr. Mark Bell, University of California, Davis
Dr. Michael Reid, University of California, Davis
Dr. Dianne Barrett, University of California, Davis
Dr. Alan Bennett, University of California, Davis
Dr. Patrick Brown, University of California, Davis
Dr. Steve Brush, University of California, Davis
Dr. George Wilson, North Carolina State University
Dr. Adel Kader, University of California, Davis
Dr. Robert Paull, University of Hawaii at Manoa
Dr. K.V. Raman, Cornell University

2. International Advisory Board.

The Horticulture CRSP appointed members to its International Advisory Board (IAB) in spring 2010. The IAB is the senior advisory council of the Horticulture CRSP. The purpose and role of the Horticulture CRSP IAB was to advise the ME on all major aspects of the program including setting priorities, sub-awarding of RFAs, technical and management approach to implementation, budget allocation and ensuring that USAID's Global Horticultural Assessment (GHA) and Horticultural CRSP objectives were met. The IAB looks at the big picture and offers advice and recommendations to the ME for their guidance and consideration.

Membership of the IAB ranges from eight to twelve members and covers major geographical regions, Horticulture CRSP partner universities, other US and international universities, international agricultural research centers and the private sector. The Director of Horticulture Innovation Lab and the USAID AOR will serve as ex-officio members. Members of the IAB for the first year were:

Dr. George Wilson, North Carolina State University, Chair
Dr. Lusike A. Wasilwa, KARI, Kenya, Vice Chair
Dr. Deborah Pierson Delmer, Private Consultant (Biotechnology)
Dr. Adel Kader, University of California, Davis
Dr. Poonpipope Kasemsap, Kasetsart University, Thailand
Dr. J.D.H. Keating, Director General, AVRDC
Dr. Norman E. Looney, Chair, GlobalHort
Dr. Howard Yana Shapiro, University of California, Davis
Dr. Larry Paulson, USAID, Ex-Officio

In 2011, two additional members were added to the IAB. They were:

Dr. Linus Opara, University of Stellenbosch, South Africa
Dr. Josette Lewis, Arcadia Biosciences, Inc., California (Dr. Lewis was previously Director of Agriculture, USAID).

Ex-officio members of the IAB included Dr. Jim Yazman and Dr. John Bowman from USAID (They were the AOR from USAID for Horticulture Innovation Lab). The Director of Horticulture Innovation Lab was an ex-officio member.

In 2012, Dr. Lusike A. Wasilwa became the Chair and Dr. Josette Lewis was designated as the Vice Chair of the IAB. Dr. Adel A. Kader passed away in November 2012; therefore, the IAB currently has only nine members. In 2012, ex-officio members from the USAID AOR were Drs. John Bowman and Saharah Moon Chapotin. The Director of the Horticulture Innovation Lab continues to be ex-officio.

At the end of the 2012 Horticulture Innovation Lab annual meeting Drs. Lusike A. Wasilwa, George Wilson and Poonpipope Kasemsap ended their terms of office. In their place, the newly appointed IAB members are: Dr. Julio Lopez (Director of Center in Zamorano, Honduras, one-year term), Dr. Robert Paull, University of Hawaii at Manoa (as Partner University for a three-year term), and Dr. Sally Smith (University of Adelaide, soil biologist, three-year term).

It is odd that the Director of the Horticulture Innovation Lab and the AOR of USAID are ex-officio members of the IAB, while the Director of the Centers and the partner university staff are full members of the IAB. Members of the IAB also apply and compete for projects and funding. To the EET, this clearly represents a conflict of interest.

Recommendation 1. The EET recommends that the ME carefully consider recruiting clearly accomplished people from different horticulture specialty areas from both the public and private sectors to serve as members of the IAB with no conflicts of interest.

In personal discussions with the EET, several members of the IAB expressed that the IAB should have a stronger role and more active participation in monitoring and evaluation of the projects. However, as the name indicates, the IAB is only advisory and therefore, the IAB should review the progress and planning by the ME and offer intellectual, strategic and scholarly advice and guidance to the ME to steer them in the right direction.

III. Management of Horticulture Innovation Lab

Technical Leadership

1. *What are the examples of technical leadership displayed by the ME?*

   USAID approved the Leader with Associates Award to University of California, Davis for the Horticulture Innovation Lab in October 2009. The ME at University of California, Davis assembled Program Council to guide the technical activities of the Horticulture Innovation Lab until the IAB was appointed. The Program Council was responsible for 1) selecting and recommending appropriate IIPs, 2) advising the Director on technical and management issues related to the implementation of IIPs and 3) appointing members of the IAB who will assume the roles and responsibilities of the Program Council. The Program Council included members based on their technical expertise in horticulture and international experience. The members were from North Carolina State University, Cornell University, University of Hawaii and University of California, Davis. Four members of the ME and the USAID AOR served as ex-officio on the Council.

   Since the number of RFAs received was substantial, to ensure openness and transparency the ME assembled a large number of external, international volunteer reviewers to review the RFAs for IIPs. Through this process the ME was able to select diverse projects that covered a broad range of vegetables, fruits, and flowers, and a range of subject matter areas such as production, protection, postharvest, nutrition, food safety, gender and value chain. At the same time they included a number of land grant universities in the US and a large number of host country participants from universities, the private sector and NGOs. Recognizing the complexity of horticulture, a number of innovative "leapfrog" technologies have been identified. These technologies can minimize or eliminate constraints, or can reduce input costs that restrict the smallholder farmers from achieving maximum profitability in the production and marketing of high-value horticultural crops Such selection of IIPs provided wide visibility for Horticulture Innovation Lab.

Horticulture includes a wide array of crops (for example, vegetables, fruits and flowers) and a range of research areas including production systems, nutrition, postharvest technologies, processing and marketing and the value chain. Therefore, it is logical for the ME to embark initially on a large number of IIPs and EPs, which are short-term (one year) in nature but in which the adaptive research addressed is sharply focused. Nearly 60% of the IIPs were successful.

The composition of the ME changed over the years. As mentioned in the Organization, Structure and Function, Director Dr. Von Ross retired and was replaced by Dr. Elizabeth Mitcham and Ms. Amanda Crump assumed the Associate Director position. The Program Council was replaced by the IAB. Initially, Dr. George Wilson was the Chair of the IAB. When his term ended, Dr. Lusike Wasilwa became the Chair and Dr. Josette Lewis was Vice Chair for IAB. From the USAID's side Dr. Larry Paulson was the AOR in the beginning. Dr. Jim Yazman and Dr. John Bowman replaced Dr. Larry Paulson. Currently, Dr. John Bowman and Dr. Saharah Moon Chapotin are the AOR from USAID. The ME made necessary adjustments to align themselves with the above changes. The Feed the Future alignment from USAID required the ME to see that the Horticulture Innovation Lab projects focused on the new directions and reduced number of countries around the world.

Within three-and-one-half years the ME has successfully brought together forces in three major geographical regions -SE Asia, Latin America and Africa- and organized Centers in Kasetsart University in Bangkok, Thailand, Zamorano University in Honduras and Kenya Agricultural Research Institute in Thika, Kenya. These three hubs will serve as technical and training knowledge development and dissemination innovation labs to reach the Feed the Future countries in each of the regions. The USAID Missions in the region have a mechanism to collaborate with the Horticulture Innovation Lab using the Centers as the hub.

2. *How well has the ME balanced research, implementation activities, training and capacity building given the amount of funding provided?*

In reviewing the portfolio of activities, the EET determined that the allocation of resources for research was 60%, for implementation was 20% and training and capacity building was 20%. Since the Horticulture Innovation Lab is relatively new, the allocation for both basic and applied research is rather large and is necessary to build a knowledge base. The allocation for basic research is only 20%. It includes for example, the seed drying beads (Bradford, PI) and the diagnostic tool development for identification of *Phytophthora* in horticultural crops (Ristaino, PI) among others. The remaining 40% of resources is allocated for applied/adaptive research that has taken available technology and worked to verify its local adaptation in specific locations (improved tomato and chili varieties for Central America Nienhuis, PI, grafting technology to overcome soilborne diseases in vegetable crops Kleinhenz, PI). Implementation efforts should continue at the current level of allocation (20%) in the future. Training and capacity building is currently a small proportion (only 20%) of the budget allocation. As the research matures and the outputs are emerging, there is a need to have trained manpower to effectively disseminate the research outputs to the farmer. Also, farmers need to be linked to the markets. The proportion of training and capacity building activities is expected to slightly increase in the future. Instead of Horticulture Innovation Lab entering into dissemination directly, it should be the responsibility of the Missions and the NARS to pick up the promising outputs from research and disseminate them to the farmers. The EET feels that the ME has very well balanced research, implementation activities, and training and capacity building considering the amount of resources allocated to Horticulture Innovation Lab.

3. *How has the ME built on earlier investments? What can be done to capitalize on these to broaden or accelerate progress?*

   Initially the ME approved and awarded 15 IIPs to 10 US universities for one year duration (2010-2011). There were 10 EPs awarded to eight US universities for one-year duration (2010-2011). Two of these projects were extended to two years (2010-2012). Four of the successful IIPs and EPs were extended as continuation projects. Two of them, namely Sustainable Technology for Orange and Purple Sweet Potato in Ghana (STOPS) (Bonsi, PI) and Regional Capacity Building in *Phyophthora* Diagnosis in seven Latin American countries (Ristaino, PI) were extended to two-year periods (2012-2014). Two others, namely Sustainable Development of Horticultural Crops in Zambia (Simon, PI) and Delivering Vegetable Safety Education Through Established Social Networks in Latin America (LeJeune, PI) were extended for two years (2012-2014). For the above two projects there was a one year no-cost extension given (2011-2012). Furthermore, two of the IIPs were extended to accelerate their progress and to cover a wide geographical area, and they became CP for three years (2011-2014).

   Some technologies from past investments appear very promising and have relevance and application in other Feed the Future countries. For example, The HARE Network: Increasing Food Safety and Creating a Niche Market for Smallholders in Vietnam (Trexler, PI) using the EMINA as a bio-fertilizer and bio-pesticide as demonstrated in Vietnam has considerable merit and potential for use in countries like Cambodia, Bangladesh and Nepal as well as in African countries. Information on the outcome of these technologies and the success stories should be disseminated widely to other countries to stimulate their interest so that they can examine the technologies under their conditions to assess their value to improve safe vegetable production. Research is also needed to better understand the nutrient composition and pesticide properties of the EMINA, which are largely unknown. Observations of the EMINA-applied plots demonstrated that the technology works – the vegetable and fruit crops were vigorous, healthy and productive. However, the mechanism of their action needs to be understood. Similarly, the Postharvest Training and Services Center established in the AVRDC Regional Center in Arusha, Tanzania has excellent facilities and has already trained a large number of trainers. These trainers have gone back and established their own training facilities and the trainers are training a large number of farmers. There is an excellent multiplier effect. It is a model that can be followed for other regions such as Asia and Latin America, probably in the Centers.

Partnering with the private sector is another means by which the outputs from earlier investments can be utilized to accelerate and broaden the scope of adoption by the farmers. The seed-drying project has taken this approach and has partnered with Rhino Research Group in Thailand, which is now reaching out and establishing marketing agents for drying beads for drying vegetable seeds. The private sector will develop innovative ways to market their product so that it can have broader impact. Similarly, the African Agricultural Research Center in Arusha, Tanzania is conducting research in collaboration with Horticulture Innovation Lab in Developing Low Cost Pest Exclusion and Microclimate Modification Technologies for Smallholder Vegetable Growers (Ngouajio, PI). Sumitomo Chemical Company has joined A to Z Textiles (mosquito net manufacturing company) in Arusha to establish Vector Health International, and they are now exploring the simple protective nets to exclude pests to produce safe, pesticide free vegetable crops. Such cooperation is a win-win situation for broadening the outputs of Horticulture Innovation Lab to reach the Feed the Future country vegetable farmers. This project has also leveraged additional support from CIRAD in France for graduate students. Another example is the successful CoolBot technology that has attracted the attention of CIP and has joined with Horticulture Innovation Lab, using a sub-grant from the Mission in Bangladesh, to examine and use the technology for storing potatoes.

4. *How does the ME continue to be forward thinking about research ideas and plans?*

The ME has regular weekly meetings to discuss the events that have occurred and the issues that have arisen in the implementation of the Horticulture Innovation Lab. One IAB member, Dr. George Wilson, joins the weekly meetings of the Horticulture Innovation Lab. During the weekly meetings the ME discusses new research ideas and plans. The Trellis Graduate Student participation in the research and development portfolio, which has become very popular and very rewarding, is an example of an outcome of these discussions,

The IAB reviews the research progress of the projects and looks at the big picture and offers recommendations and guidance to refine and strengthen the research. One such outcome was the Comprehensive Long-term Project (CP).

The USAID AORs periodically reviews the progress of the projects and discusses with the ME and offers suggestions and new ideas for research. The Feed the Future initiative and its objectives have made the ME move forward with new ideas and align themselves with the new focus and new geographical boundaries.

The Director and Associate Director have taken part in many high level international events including the Symposium of Horticulture in Europe, the Indian Horticultural Congress, two All-African Horticultural Congresses and several other events. They have made presentations at those events and received feedback and research ideas and identified opportunities for potential collaboration with other groups. Collaboration with CIRAD on low-cost pest exclusion technology is one such outcome. Additionally, the AOR has represented the project at global research conferences (SEAVEG – Thailand 2012, ASHS 2011/2012, Global Post Harvest Vegetable Conference – Malaysia 2013, etc.), so the effort gets significantly wide global exposure.

The Director of Horticulture Innovation Lab and the AOR had discussions with the US LAC Bureau and succeeded in getting an Associate Award entitled "Assessing Constraints and Opportunities for the Horticulture Industry in Central America (Guatemala and Honduras)". They expect additional awards from the Bureau when the assessment is over. The Horticulture Innovation Lab plans to conduct postharvest training and additional disease diagnostic training at the Center in Honduras funded by an award that the ME received from USDA-FAS in collaboration with the Center at Zamorano, Honduras.

The Director of Horticulture Innovation Lab is also currently serving as the Chair of all the Feed the Future Innovation Labs. Through this opportunity the ME is able to get a feeling for the research directions, research areas and plans of the other Innovation Labs. The ME has plans to interact with other Innovation Labs and engage in collaborative projects with other Labs. One such collaboration is a focus project with SANREM Innovation Lab on use of energy in irrigation (which is in the pipeline).

Establishment of the Centers in SE Asia, Latin America and Africa will help share horticultural research ideas within the region as well as between regions.

The ME also has an annual retreat in which they brainstorm research ideas and make appropriate plans for the next year. During brainstorming sessions the ME looks at the technologies already available in the Global Horticulture Knowledge Bank in relation to the constraints encountered by smallholder vegetable farmers in different regions of the world and tries to identify appropriate technology for adaptive research. The Trellis Project also tries to match graduate students' expertise with host country farmer constraints to assist the farmers and local NGOs in Feed the Future countries.

5. *How has the ME promoted and maximized values such as collaboration, capacity building and outreach among sub-awardees?*

   One of the best examples of the ME promoting and maximizing the value of collaboration, capacity building and outreach among sub-awardees is the train the trainer project at the Postharvest Training and Services Center (PTSC) at the AVRDC Regional Center in Arusha, Tanzania (Barrett, PI). Thirty-six postharvest specialists ("trainers", 53% women, from eight Sub-Saharan African countries) were trained over 18 months and took 10 courses offered by the PTSC in 2011. Upon return to their countries, they in turn trained 8,378 people who in turn trained an additional 3,600 farmers. In total, 12,338 people were trained and benefitted from this program.

   Another example is the EMINA bio-fertilizer and bio-pesticide use in The HARE Network: Increasing Food Safety and Creating a Niche Market for Smallholders project (Trexler, PI) in Vietnam. Through a "train the trainer" approach, a women's group has trained people in neighboring villages in their commune, and they have plans to extend the technology to neighboring communes even after the program ends. The technique of producing and using EMINA for safe vegetable production is multiplied and expanded within the country mainly due to the attractiveness and benefit it brings to the smallholder farmers who produce vegetables and fruits.

   The establishment of Centers in three strategic locations in SE Asia, Latin America and in Africa is a step in the right direction to promote and maximize collaboration within the region, enhance capacity building and to reach out to more smallholder vegetable and fruit farmers in Feed the Future countries in each of the region.

6. *Has the ME developed a mechanism to ensure that local, national and regional needs and priorities will continue to be incorporated into the development of the research agenda? What are these mechanisms?*

   The ME has established the three Centers, one each in SE Asia, Latin America and Africa. The Latin American Center in collaboration with the LAC Bureau, through an Associate Award, has a project to Assess Constraints and Opportunities for the Horticulture Industry in Central America (Guatemala and Honduras). The results of this exercise will identify the local, national and regional needs and priorities for the LAC region.

The ME is fully aware of the studies on the constraints and needs of the horticulture value chain in the Feed the Future countries in the Africa region. In addition, the ME has the results and outputs from various IIPs, EPs and PPs. The CP on African Indigenous Vegetables (Weller, PI) has a large number of cooperators. The ME also makes field visits to various projects to get firsthand information about the progress of the projects and at the same time to assess the research priorities and farmers' needs at the local, national and regional levels. Armed with such diverse information, the ME can incorporate the research needs according to the priorities for each local, national and regional area in the research agenda.

During the horticulture needs assessment workshops in each of the three strategic regions prior to the establishment of Horticulture Innovation Lab, a wealth of information on constraints, priorities and research needs was accumulated. However, there is a need to update such information periodically, as is being done for the LAC region, to ensure that current and future needs are addressed.

The ME also gathers information on the constraints, research priorities and needs through their participation in national, regional and international horticultural symposia, workshops and meetings, and they help to shape the research agenda.

The EET has conducted a survey of the host country PIs through the help of USAID and Dr. Timothy Dalton of Kansa State University. The results of the survey provide some valuable information concerning the priority crops, priority constraints and the research needs, and we hope that USAID and the ME will take note of this information in designing the future research agenda.

Recommendation 2. The EET strongly recommends that the ME review the results of the survey of host country PIs in setting the research priorities and developing the future research agenda.

7. *How well has the ME facilitated the participation of new partners?*

The ME has an open and transparent policy in reviewing the RFAs using international volunteer reviewers, which helps in bringing new partners on board. The ME also widely publicizes the RFAs and provides prospective partners with detailed guidelines on the preparation of the proposals. The requirements are clearly spelled out. During their visits to various countries, the ME members discuss Horticulture Innovation Lab priorities with potential new partners who are interested in working with Horticulture Innovation Lab and encourage them to cooperate with one or more US PIs.

The ME also proactively engages themselves with other Innovation Lab teams and explores the possibility of having them as complimentary partners on joint venture projects. Such projects will have synergy and avoid duplication of efforts. Recently, Horticulture Innovation Lab has joined with the SANREM Innovation Lab to have a project on irrigation in Horticulture (Reyes, PI).

The ME has an open door policy for bringing on board new partners to strengthen the value of Horticulture Innovation Lab. Therefore, the ME encourages the US PIs to explore the possibility of including qualified and responsible new partners who can take active roles and promptly deliver outputs.

In the beginning, nearly 33% of the IIPs were from University of California, Davis, since reviewers rejected a majority of proposals from other institutions. However, now the PPs and continuation projects are from diverse US universities with new partners.

8. *How has the ME engaged USAID bilateral Missions, other donors and partners (i.e. World bank, IFAD, FAO. CGIAR, NGOs, the Private sector) in the Innovation Labs research and capacity building activities? Give examples. How might engagement be increased?*

The Horticulture Innovation Lab is only three-and-one-half years old. The ME is very much aware that they need to engage and establish a warm relationship with the USAID Missions in each of the countries where they are working. The ME has made it a point to personally meet with Mission staff whenever they visit a country – at a minimum, requests for meetings with Mission staff are always made. The ME has met with the staff of certain Missions several times. They have established good relationships with several Mission staff, and some of them have indicated to the ME that funds will be available in the future to work with Horticulture Innovation Lab. The ME was successful in getting an Associate Award from the LAC Bureau to assess the constraints to the horticulture industry in select Central American countries. After the assessment is complete, Horticulture Innovation Lab expects to have additional awards. The ME also secured a pass-through of Bangladesh Mission funds from CIP to work on cool storage using Horticulture Innovation Lab's CoolBot technology. This is considered to be Mission sub-grant through CIP.

The ME has leveraged funds from CIRAD to support graduate students working on low cost pest exclusion project in Benin and Kenya.

Due to their excellent work with Horticulture Innovation Lab Weller group (Purdue University) was able to secure support for three years from CSIRO in Australia for a project, "Best Practices for Horticultural Crop Production in Tanzania, Kenya, Mozambique, Malawi"

Similarly, for varietal development and seed systems in horticultural crops, the GTZ Global Program has provided additional support..

The EET met with the Mission staff in Cambodia and had extensive discussions. They would like the Horticulture Innovation Lab to interact more frequently with them and inform them of Horticulture Innovation Lab plans and activities regularly. They also mentioned that in their Harvest Plus program they are working with nearly 20,000 farmers in Cambodia, and most of them grow vegetables. This network of farmers is an ideal platform for Horticulture Innovation Lab to work with. In the future, the Cambodia Mission staff would like to see research proposals involving Cambodia in advance of Horticulture Innovation Lab approval so that they may provide their opinion as to whether the proposals meet with their country program objectives.

Recommendation 3. The ME should be congratulated for its efforts to engage with the Missions in host countries. The EET strongly recommends that the ME proactively continue engagement with the Missions and. where it is possible, inform and involve the Missions in the project review process (as requested in Cambodia) so that they feel that they have an obligation and ownership for the projects. The ME also should encourage the PIs and the host country representatives to periodically meet with Mission staff and apprise them of projects' progress and showcase the significant outputs.

The Director and the Associate Director participated in a number of national, regional and international symposia and conferences and met with various donor agencies, foundations, international organizations and the private sector people interested in horticulture, food security, poverty alleviation, prevention of hunger and malnutrition and apprised them about Horticulture Innovation Lab. All of them appreciated the work Horticulture Innovation Lab is doing and Horticulture Innovation Lab's accomplishments. The ME will continue to meet with them and try to establish fruitful linkages to support the Horticulture Innovation Lab.

Recommendation 4. The EET recommends that the ME regularly invite all of the public and private donor agencies such as FAO, World Bank, IFAD, CGIAR, Gates Foundation, and NGOs to participate in their workshops and annual meetings. In addition, the ME should regularly distribute their publications, press releases and significant findings to the above agencies so that they are aware of the accomplishments of Horticulture Innovation Lab.

Administration

1. *What systems are in place to keep research activities on track according to program goals?*

   The Horticulture Innovation Lab's ME has clearly defined program goals and objectives as explained in the Organization, Structure and Function section of this document. The US PIs and the host country PIs are well aware of the program goals, and they follow them in implementing the research activities. Each project has a project implementation plan (PIP). Each activity has a schedule and detailed plan, which are easy to follow and monitor. The PIs submit half-yearly and annual reports to the ME. The ME reviews the reports carefully to see that the research activities are progressing according to the prescribed work plan and program goals (PIP). If the reported activities are in accordance with the work plan, the ME merely acknowledges the receipt of the report. If there are issues or concerns in the report or if the progress is not according to the work plan and program goals (e.g., if the project is lagging behind in its time schedule for implementing the research activities), then the ME inquires of the PI, through telephone, personal visit or email, the reasons for the issues and plans to address the problem. Extenuating circumstances such as weather, personnel issues or funding may hamper progress. The PIs usually explain such situations to the ME and request additional time to catch up with the research activities. In a majority of cases, the review system has kept track of the progress of research activities according to program goals. Problems were resolved using no-cost extensions of the projects to allow the completion of research activities. In only one case, namely, Training Urban and Peri-urban Horticultural Growers in Cropping Systems, Pre- and Postharvest Handling and Marketing Techniques in Cambodia, Vietnam and Thailand' institutional problems in the PIs institution resulted in the cancellation of the project.

   The IAB also reviews the progress of the research activities and sees the big picture to make sure that the Horticulture Innovation Lab is on the right track with all the ongoing research activities. The IAB provides advice and guidance to the ME so that the system is working properly to address the goals.

   The USAID AOR also visits various project sites to observe firsthand the research activities, while comparing them to Mission project activities in vegetable production and looking for synergies. He also receives regular progress reports and progress against Feed the Future indicators and targets. If there are issues, he also intervenes and provides support and guidance to resolve the issues.

2. *What are the roles and functions of advisory committees? How they have been effective and efficient?*

   The Horticulture Innovation Lab appointed members to its International Advisory Board (IAB) in spring 2010. The IAB is the senior advisory council of the Horticulture Innovation Lab. The purpose and role of the Horticulture Innovation Lab IAB is to advise the ME on all major aspects of the program including setting priorities, sub-awarding of RFAs, technical and management approaches to implementation, budget allocation and ensuring that the USAID's Global Horticultural Assessment (GHA) and Horticulture Innovation Lab objectives are met. Membership of the IAB ranges from eight to twelve people and covers major geographical regions, Horticulture Innovation Lab partner universities, other US and international universities, international agricultural research centers and the private sector. The ME of the Horticulture Innovation Lab and the USAID AOR serve as ex-officio members. Members of the IAB for the first year were:

Dr. George Wilson, North Carolina State University, Chair
Dr. Lusike A. Wasilwa, KARI, Kenya, Vice Chair
Dr. Deborah Pierson Delmer, Private consultant (Biotechnology)
Dr. Adel Kader, University of California, Davis
Dr. Poonpipope Kasemsap, Kasetsart University, Thailand
Dr. J.D.H. Keating, Director General, AVRDC
Dr. Norman E. Looney, President ISHS
Dr. Howard Yana Shapiro, University of California, Davis
Dr. Larry Paulson, USAID, Ex-Officio

The IAB met once in Singapore soon after the inception workshop in April 2010. The recommendations of the IAB to the ME included:

- content and format of annual conferences;
- linkages with USAID Missions;
- capacity building of institutions;
- project priorities;
- sustaining projects after the Horticulture Innovation Lab funding ends;
- regional centers of excellence;
- information management;
- linkage with CGIAR system and projects;
- linkage with nutrition and health;
- linkage with Global Horticulture Initiative (GHI).

In August 2011 at the International Horticultural Congress in Portugal, an unofficial meeting of the IAB was organized since most of the IAB members were present.

The Horticulture Innovation Lab IAB chair, George Wilson, regularly participated in the weekly meeting of the ME [by telephone connection] and offered his advice and guidance. The IAB members highlighted Horticulture Innovation Lab in various international meetings that they attended.

In 2011 two additional members were added to the IAB. They were:

Dr. Linus Opara, University of Stellenbosch, South Africa
Dr. Josette Lewis, Arcadia Biosciences, Inc., California (Previously, Dr. Lewis was Director of Agriculture, USAID.)

Ex-officio members of the IAB included Dr. Jim Yazman and Dr. John Bowman from USAID. (They are the technical representatives from USAID for Hort CRSP.)

The IAB met following the Horticulture Innovation Lab annual meeting in University of California, Davis, CA in April 2011. After reviewing progress, the IAB presented the following seven recommendations to the ME:

- Assess project impact, collect accurate and complete baseline data;
- Showcase successful technologies and redefine Regional Centers of Excellence as Demonstration and Training Centers;
- Focus on fewer subject matter areas and fewer projects with clear accomplishment goals;
- Choose and select the best among the 30 current projects and continue their funding to make an impact;
- Reserve some funds for discrete technology transfer programs;
- Create at least one signature project during the next three years;
- Be part of an important Feed the Future program by building on new technologies, strengthening partnerships and developing strong activities around institutional and human capacity building.

In 2012, Dr. Lusike A. Wasilwa became the Chair and Dr. Josette Lewis was designated as the Vice Chair of the IAB. Dr. Adel A. Kader passed away in November 2012 and therefore, currently the IAB has only nine members.

The IAB met in Nairobi Kenya on May 10, 2013. Drs. Lusike A Wasilwa, George Wilson and Poonpipope Kasemsap ended their terms. In their place Dr. Julio Lopez Montes, Zamorano University, Honduras, Dr. Sally Smith, Australia and Dr. Robert Paull, University of Hawaii at Manoa were selected as new members.

As mentioned earlier, the responsibility of the International Advisory Board, as the name indicates, is advisory in nature. They see the big picture and provide overall guidance to the ME without going into the routine management operations. The ME respects the recommendations of the IAB and acts accordingly. The membership of the IAB, in some respects, does not make sense. The members of the partner universities and the Directors of the Centers are members of the IAB. They are also competing for the funds from Horticulture Innovation Lab for projects. We see this as a potential conflict of interest. As per the organizational structure, the Directors of the Centers are under the Director of the Horticulture Innovation Lab, who is an ex-officio member of the IAB, while the Directors of Centers are full members of the IAB. This, also does not make sense. Therefore, the EET recommends that the ME recruit IAB members with no conflicts of interest. (See Recommendation 1 in the Organization, Structure and Function of the Management Entity section of this document.)

Although some of the IAB members would like to see an expanded role for the IAB, since it is not a regular board, the EET feels that the IAB's current responsibility and functions are effective and efficient.

3. *What major challenges has the ME faced and how have they been addressed? Give examples.*

At a critical point in time, at the end of 2011, Dr. Ron Voss, the founding Horticulture Innovation Lab Director, retired. The Horticulture Innovation Lab had completed its second year. It marked the transition from 15 one-year IIPs and 10 one-year EPs to a portfolio of 5 three-year PPs, 10 one-year Trellis projects and two three-year CPs. The new Director, Dr. Elizabeth Mitcham took over the challenges along with the new Associate Director, Ms. Amanda Crump. With forward-looking plans, they approved four continuation projects (which were previously either IIPs or EPs) that will be completed in 2014. In addition, they have approved two focus projects, and a new series of Trellis projects is in the pipeline for approval.

The Director has visited and met with the Mission staff in several countries and established a good working relationship between the Horticulture Innovation Lab and the Missions. Since USAID has indicated that there is nearly US$30 million available with the Missions, which can be leveraged for Horticulture Innovation Lab, the ME has made it a point and urged its PIs to brief the Missions about the progress of the projects. The Horticulture Innovation Lab was successful with the Bureau of LAC in getting funding to assess the Horticulture Industry in Latin America. Upon completion of this assessment there may be additional Associate Awards from the LAC Bureau. A sub-grant through CIP in Bangladesh is being used to store potatoes in Bangladesh using Horticulture Innovation Lab's CoolBot Technology), while comparing performance to other storage systems.

The USAID AOR has been changed three times within the last three-and-one-half years. In the beginning, the AOR was Dr. Larry Paulson who supported the Horticulture Innovation Lab in all its initial start-up activities. Then, Dr. Jim Yazman, a livestock specialist, became the AOR, which was a challenging transition for the Horticulture Innovation Lab since his guidance and direction were minimal. Currently, Drs. John Bowman and Saharah Moon Chapotin are the AORs from USAID. They are very active and take special interest in the activities and progress of Horticulture Innovation Lab. The ME has made the necessary adjustments in spite of such frequent changes in the USAID AORs.

USAID recently announced its new Feed the Future program. The ME reacted wisely and aligned its research and capacity building activities with the Feed the Future objectives. It has also narrowed its geographical focus to Feed the Future countries. The ME should explore avenues to exploit USAID's new alliances with the private sector (presented by USAID at the Horticulture Innovation Lab 2013 annual meeting). There are new horticulture value chain USAID projects approved for Winrock in Nepal, FINTRAC in Kenya, DAI in Liberia and Haiti and two Feed the Future programs managed by local NGOs in Guatemala. The ME should, if possible, establish linkages with these programs and complement their activities. It is a great challenge as well as an opportunity.

The ME needs to carefully study the new developments at the USAID and try to see the comparative advantage of the Horticulture Innovation Lab in developing an integrated portfolio with loss assessment surveys, needs assessment and intervention points, economic cost quantification, stakeholder consultation workshops, and technology adoption and development. The program should also address the safe and nutritious foods, agribusiness, linking smallholder farmers to markets and enabling horticultural trade.

4. *How have administrative/management problems been resolved by the ME? Give examples.*

The inception workshop was planned to be in Bangkok, Thailand. At the last minute, the local political situation and the accompanying civil unrest posed a serious problem. The ME, in consultation with USAID and the host, Dr. Poonpipope Kasemsap, quickly negotiated with the National Institute of Education at Nangyang Technical University in Singapore and made necessary arrangements to have the workshop in Singapore. Within a short span of time, the ME was able to change all of the logistic arrangements for the travel of all the participants to Singapore and arrange accommodation. The ME should be congratulated for the successful conduct of the inception workshop, May 16-18, 2010. Ninety-five participants from 34 countries joined the workshop

In opening the Regional Center of Innovation in Kasetsart University in Bangkok, Thailand, although the Center was officially opened, the agreement was not signed. The ME pursued with the Director patiently to get the agreement signed. The agreement document was extensive, and therefore the legal department at the university needed to carefully review it before the authorities could sign the document. Finally, at the end of April 2013, the agreement to establish the Center in Kasetsart University was signed.

In evaluating various projects, the ME found that the project from Tennessee State University, was not making any progress. After discussing the situation, the ME gave two extensions so that the project could get moving. However, due to institutional problems in handling the funds, the project could not make any progress, and therefore the ME had no other recourse than to cancel the project.

5. *In general, what has been the management style of the ME regarding principal investigators and sub-awardees? Are there any areas that could be improved?*

In general, the management style of the ME regarding the PIs and sub-awardees is open and transparent. The requests for proposals are widely publicized. International volunteer reviewers are utilized to provide an unbiased review of the proposals without conflicts of interest. The successful pre-proposals are asked to prepare full proposals, and they are reviewed for their merits and the final awards are made. The terms and conditions of the awards are clearly stated. The sub-awards should be clearly mentioned in the original proposal. Any deviation from proposed sub-awardees during the implementation process requires justification and approval from the ME. A half-yearly report is required from each of the PIs and progress indicators are provided to the PIs. The ME also makes on-site visits to the PIs, as well as the host country sub-awardees, to gain firsthand knowledge of the implementation of the programs. During the field visits, the ME determines any issues or concerns from the sub-awardees and tries to address those issues for smooth operation of the projects. The PIs and the sub-awardees, in general, feel that the ME is doing an excellent job. The ME gives considerable freedom to the PIs in making slight modifications that do not affect the overall output of the projects. Only when it comes to major changes in project direction or fund allocation or use, is ME approval required. When they are justified, invariably, the ME approves such requests.

6. *Is the administrative cost of the Innovation Lab appropriate for its size? Is the present structure cost effective and efficient?*

For the Horticulture Innovation Lab, University of California, Davis charges a reasonable overhead rate, which is in line with other Innovation Lab projects. The majority of the staff of the Horticulture Innovation Lab at University of California, Davis are part-time employees of the university. Office Assistant and Event Planner Diana Puccetti, Communications Specialist Brenda Dawson and Regional Center of Innovation Specialist Britta Hansen are the only full-time employees. Other ME staff spend 5% to 50% of their time for Horticulture Innovation Lab, including the Director (50%). The Financial and Accounting area is covered by two staffers, each of which has a 50% appointment. Considering the responsibility of the position, the amount of travel required, and the extent of administrative and management duties to manage the Horticulture Innovation Lab, a full-time Director should be considered for the future. Currently, the structure is cost-effective and efficient.

7. *Has communication by the ME with collaborating partners been effective?*

The ME has excellent communication with its partners. To be more effective, the ME may encourage and stimulate cross-PI communication in the US and communication and exchange of information, related to significant outputs from projects, between co-PIs within the country and between countries. Encouraging and facilitating such exchange can have a multiplier effect in disseminating promising technologies among Feed the Future countries around the world.

Financial Management

1. *How well has the ME managed the financial aspects of the Innovation Lab? Are the US and host country collaborators satisfied with financial management by the ME? How have problems been resolved? Give examples.*

   The ME has managed the financial aspects of the Horticulture Innovation Lab with great care and professionalism. The Financial Division at the Department of Plant Sciences in the CA&ES at University of California, Davis handles all the financial matters related to the Horticulture Innovation Lab at University of California, Davis. Ms. Heather Kawakami, Business Unit Manager and Ms. Sabrina Morgan, the Account Manager are the two members of the ME working with the Director of Horticulture Innovation Lab.

   An annual budget is allocated to the university to which the PI is attached, on a cost reimbursable basis. Most US institutions work on a cost reimbursable basis. Initially, 25% of the total budget is advanced to the PIs. The PIs should provide a cost report for 75% of the annual budget before the next advance is sent to them. Normally, the business office sends 25% of the annual budget upon receipt of the cost report. The PIs have a bank account specifically for the Horticulture Innovation Lab, and funds are sent to that bank account. This only applies to host country institutions that do not have working capital. Also, it is only University of California, Davis's policy for advancing funds for this project—non-University of California, Davis PIs have to work within the structures of their own institutions for any advancement of funds. The mechanism at each US Institution can vary based on the Policies and Procedures at that Institution. No funds are sent to any personal account either in the US or in host countries.

   Any tuition advances exceeding the 25% normal advancement for host country institutions under the University of California, Davis PIs is built into the contract. All host country PIs receive funds from their US PIs. Country PIs must send invoices and cost reports for expenditures incurred (not actual receipts but they should keep the receipts in case they are required) before the next tranche of 25% funds can be sent to them. Some of the national PIs are behind and some are ahead in sending the invoices, and the accounting office has not encountered any serious problems or complaints so far. (Note: Each U.S. Institution may have their own mechanism for handling the advancement of funds; however, all should require some sort of cost report to verify expenses.)

   For Regional Centers of Innovation in KARI in Kenya and KU in Thailand, 25% of the budget is advanced and the Centers have to send their invoices for expenditure for at least 75% of the amount advanced before the next 25% can be sent to them. The Center in Zamorano, Honduras has working capital and thus does not require advance payments. USAID requires a lot of paper work while the Horticulture Innovation Lab requires only minimal paper work. The ME at University of California, Davis has not encountered any problem in getting the annual allocation from USAID. The two financial staff participate in the annual meeting where they brief and discuss financial matters with all the PIs and the host country co-investigators, listen to their concerns and try to sort out any issues so as to maintain a smooth financial flow.

Advancing funds is the biggest problem and may be risky. Delay in advancing the funds may be due to:

1. Delay in budget preparation;
2. PIs from different universities have to go through their institutional system before they can advance funds to the host country PIs/co-investigators causing some delays. For example, AVRDC is waiting for Purdue University to send the advance;
3. Sub-recipient monitoring forms are required before a contract is awarded;
4. Allocation is for each year. Some carryover from one year to the next is allowed, but it should not be too big of an amount;
5. Approval is required for partners and the PIs if the funds are not spent; otherwise they may not receive additional subsequent funding;
6. A total cost share of 25% is required from the US institution (that may in turn secure cost-sharing from their host country partners, although the Horticulture Innovation Lab does not require cost-sharing from each partner as long as the 25% is met overall).

The invoice summary for ten exploratory sub-awards from eight institutions has been reviewed. The projects operated between 2010 and 2012. Out of the ten projects, eight had no-cost extensions. All of them met the 25% cost sharing and some of them had up to 40% cost sharing.

Invariably, direct costs (which included the above costs plus the costs of salaries, fringe benefits, supplies, foreign travel, domestic travel, training travel and training) were 83 to 84% (with the exception of two projects that had 88% and one project that had 94%) of the total approved budget. Therefore, indirect costs were 6% in one case, 12% in two cases and the rest had about 16 to 17%. Five of the projects spent 98% of the funds, although some needed additional no-cost extensions to accomplish completion. One project was terminated and remaining funds were returned to the Horticulture Innovation Lab. For the four remaining projects, funds were de-obligated and returned to the Horticulture Innovation Lab after project completion.

The Centers in Thailand, Honduras and Kenya each have annual budget allocations for direct costs. The Centers charge 0 to 26.7% for indirect costs. The Centers are expected to identify partnerships and potential funding sources, which will enable them to sustain their activities beyond the initial seed money from the Horticulture Innovation Lab.

During our visit to Vietnam, the co-PI mentioned that usually the agreement comes for signature in October and that when he returns the signed agreement, the funds come to him in March-April of the following year. However, it is already April of this year, and the agreement has not come yet. The funds will also be delayed further. The EET discussed the matter with the US PI (Trexler) and learned that he is in the process of sending the agreement. Therefore, normally the delays occur on the PIs' ends rather than at the financial division. Once the invoices are received and/or other paperwork is completed, the financial division acts swiftly to send the funds.

The results of the survey, conducted by Dr. Timothy Dalton of Kansas State University, of host country sub-awardees include a number of comments. They are attached as Appendix 3. The information contained in the Appendix should be valuable for ME to consider making necessary adjustments, where possible, for improvement.

2. *How are project resource allocations made? Is the allocation appropriate?*

The Financial Management provides the content and format of project budgets. The project budget should contain the budget workbook and budget justification. The budget workbook provides a budget spreadsheet in which the budget information can be entered. The workbook allows up to 10 sub-awards, and each sub-award is linked to the main budget page. Each institution provides budget justification and cost-sharing narrative. The justifications are listed under the following format:

- Senior personnel
- Support personnel
- Travel
- Material and supplies
- Equipment
- Participant training
- Other
- Graduate student fees
- Sub-awards
- Indirect costs
- Cost sharing

The US institutions may claim indirect costs at the lesser of 20% of modified total direct costs (direct costs excluding equipment, tuition, participant training and sub-award expenses beyond the initial $25,000 for each sub-award) or their institution approved rate. If no approved rate applies, then the indirect cost rate should be zero. Administration fees requested by foreign sub-awards should not exceed 8-10%. An approved indirect cost rate agreement for each institution claiming indirect costs must be provided at the time of proposal submission. A cost sharing of 25% of federal funds is required for each project. This will be in the form of a letter and must be submitted at the time of proposal submission.

The above cost allocations made by the PIs in the proposals are reviewed by the ME for their validity and appropriateness prior to approval of the projects. The PIs have some flexibility in allocating the funds from one category to another as long as it does not alter the outcome of the objectives. However, any major changes in the budget allocation of the approved budget require the Director's approval. Specifically, the items requiring approval include international travel, purchase of equipment valued at $5,000 or more, purchase of restricted items, and shifts in funding for participant training if the budget would result in changes to the approved training activities.

Funds cannot be carried forward from one project year to another automatically. Contingent upon the status of the prime award, requests to carry forward funds should be sent to University of California, Davis for review and approval by the ME. Similarly, requests for no-cost time extensions should be sent to University of California, Davis for review and approval by the Director.

In discussions with US PIs, we learned that the allocations were appropriate. The US PI usually asks the sub-awardee from the foreign country to prepare the budget for their part and include this in the overall budget. In discussions with the host country PIs, several of them complained that the budgets were not sufficient to carry out the project activities. But when we asked who prepared the budgets for their parts, they mentioned that they did. Therefore, they underestimated their budgets and later on they felt that the budgets were insufficient. Some of the US PIs have reserved some funds that allow them to supplement host PI research activities. For example, Weller (African Indigenous Vegetables Project) was able to supplement the budget of deserving, hard-working host PIs with additional support.

3. *Has the system for reimbursement of expenditures been efficient for all collaborators? What areas need to be improved to address pipeline issues or payment lags?*

   The system for reimbursement of expenditures has been efficient for all cooperators. The PIs have no complaints about the reimbursement of expenses. The US PIs understand the USAID policies and how the system works and they are used to the procedures. Only the foreign PIs had some difficulties in getting advances from the US PIs. These issues and the causes for the delays are discussed under question 1, above.

4. *Have cost matching requirements been met by all partners? What has been the effect of these requirements?*

All partners have met the cost-matching requirements. As mentioned above, under question 2, cost-matching requirements are built into the proposals prior to approval of the projects. The cost matching provides part ownership of the projects for the host institutions, and they make a commitment to that effect through a letter. It works very well.

USAID's Role

1. *What has been the involvement and contribution of the USAID Agreement Officer's Representative (AOR)? How can it be improved?*

   The USAID Agreement Officer's Technical Representatives were Dr. Larry Paulson and Dr. Jim Yazman from 2010-2011. Dr Jim Yazman and Dr. John Bowman replaced Dr. Larry Paulson for 2011-2012. Dr. John Bowman and Dr. Saharah Moon Chapotin succeeded Dr. Jim Yazman in 2012. We understand that Dr. Larry Paulson gave full freedom for the ME to implement the initial start-up of the Horticulture Innovation Lab. He wanted to have some immediate impacts. Dr. Yazman, on the other hand, was a livestock expert and had minimal influence on the management of the Horticulture Innovation Lab. Currently, Dr. John Bowman is very active with the Horticulture Innovation Lab and actively participates with the ME in the decision making process. He also visits the field sites and observes the progress and offers his constructive suggestions. He also briefs the ME with the latest developments at USAID so that the ME can align themselves with the new initiatives of the agency. For example, the Feed the Future initiative and the New Alliance with the Private Sector have implications and directions for the Horticulture Innovation Lab.

   Since USAID provides substantial funding to private contractors such as FINTRAC, Winrock, DAI, and NGOs, the AOR may serve as an intermediary to help link the Horticulture Innovation Lab to complement their activities.

   In the request for proposals from USAID for the Horticulture Innovation Lab, it is stated that the Horticulture Innovation Lab can access an additional US$30 million from the Missions as Associate Awards. The ME is making concerted efforts to meet with various Missions and establish working relationships with them. The ME has succeeded in getting an Associate Award for assessment of the horticulture industry in Latin America from the LAC Bureau. Upon completion of this assessment, the Horticulture Innovation Lab can expect additional Associate Awards from the LAC Bureau. The AOR can facilitate the interaction between the Missions and the ME so that the Missions' activities can be complemented with Horticulture Innovation Lab activities in the host countries.

   Recommendation 5. The EET recommends that the USAID AOR serve as an intermediary between the ME and the Missions so that it can facilitate collaboration between Horticulture Innovation Lab and the Missions.

2. *How have changes in USAID priorities impacted the management and administration of the Innovation Lab? Give examples.*

   The Feed the Future initiative of the USAID has had a major impact on the management and administration of the Horticulture Innovation Lab. The Horticulture Innovation Lab's contribution to Feed the Future goals and strategies are:

   - Empowering **women with access to income** by improving horticultural crop production
   - Increasing household **production of nutritious foods** that are rich in micronutrients
   - Dissemination of technical assistance for **increased production and market access**
   - **Increased agriculture value chain** on- and off-farm through training in pre- and postharvest handling and reducing postharvest losses of nutritious foods
   - Creating an **enabling policy environment** for agribusiness growth

   The Horticulture Innovation Lab has supported 39 research projects in 36 countries including 14 Feed the Future countries. Projects have been located in **Bangladesh,** Benin, Bolivia, **Cambodia,** Chile, Costa Rica, Democratic Republic of Congo, Dominican Republic, Ecuador, El Salvador, **Ethiopia**, Gabon, **Ghana, Guatemala, Haiti, Honduras,** India, **Kenya,** Laos, **Malawi,** Mexico**, Nepal,** Nicaragua, Nigeria, Panama, Peru, **Rwanda,** South Africa, Sri Lanka, **Tanzania,** Thailand, **Uganda,** Vietnam, **Zambia** and Zimbabwe. (The countries listed in bold font are Feed the Future countries.) So far, the Horticulture Innovation Lab has supported collaborative research with more than 18 US universities and 200 organizations worldwide. In the future, the focus will be more on the Feed the Future objectives and the Feed the Future countries.

   Although the Horticulture Innovation Lab started with short-term IIPs and EPs, in response to the recommendation from the IAB and in response to the guidance and advice from the AOR, the Horticulture Innovation Lab introduced the long-term PPs and CPs for two- and three-year terms with expanded funding up to US$1 million per project. The seeds project with drying beads (Bradford, PI) and the African Indigenous Vegetables Project (Weller, PI) were the two CPs receiving US$1 million each (three-year duration).

   The Trellis Fund project has value for the money and it benefits both the US and the host countries and builds human capacity in the US as well as in the host country. The Horticulture Innovation Lab is aligned with 47 different USAID partners including host country universities, government agencies, NGOs, and USAID supported AVRDC.

IV. Research Program Focus and Output

1. *Are the depth, breadth and rigor of the research and development activities sufficient to achieve stated program goals and objectives? How could the major themes or topics be refined to increase impact?*

   The activities conducted to date have moved from short-term Immediate Impact Projects (IIPs) (one-year), to one-year Exploration and three-year Pilot Projects (EPs and PPs), and more recently to longer three-year Comprehensive Projects (CPs). The high number of IIPs (15) enabled the Horticulture Innovation lab to initially investigate a broad range of activities. Some of the successful IIPs and EPs have graduated to continuation projects (CNPs) with specified goals. Recently the ME added some focus areas, which were not covered in the portfolio such as energy related projects as new Focus Projects (FP). One such project in the pipeline is in collaboration with SANREM CRSP. Due to the focused nature of the IIPs, they were executed at some depth; although, it should also be noted that depth was not fully realized in all the IIPs, due to various difficulties encountered by the short duration of these projects. By moving to the CPs which are fewer in number, more recently, the depth of research coverage of the whole Horticulture Innovation Lab has been enhanced.. The CPs have brought together team members with different scientific backgrounds and expertise, and have integrated several research activities. However, the CPs are addressing fewer horticultural crops and fewer Feed the Future countries. Currently the Horticulture Innovation Lab has a combination of PPs, CNPs and FPs in addition to CPs. In addition, continuation of the Trellis Fund ensures that the overall balance in the depth and breadth of research activities is maintained. We believe the portfolio of projects has done a good job of achieving the stated program goals.

   As to rigor, we identified varying levels of rigor in the experimental designs within the projects. Certain projects provided good quantitative data derived from well planned and executed experiments (e.g., Seed Systems – Improving Seed Quality for Smallholders; Bradford, PI; Low Cost Pest Exclusion and Microclimate Modification Technologies for Small-Scale Vegetable Growers in East and West Africa; Ngouajio, PI). However, some experiments seemed to provide more qualitative than quantitative results. While some of this is related to the difficulties encountered when using farmers' fields to run studies, we also thought the extent of expertise was insufficient at times to adequately carry out all the experiments. For instance, some of the field trial results reported for Safe Vegetable Production in Cambodia and Vietnam: Developing the Horticulture Action Research and Education Network (HARE-Network) to Enhance Farmer Income, Health, and the Local Environment; Pilot Project (Trexler, PI and his team) at the Horticulture Innovation Lab Annual Meeting in Nairobi, did not appear to have sufficient controls or conditions to fully address the objective they sought. (This was an experiment designed to test the productivity and income generation of a new melon variety in Vietnam and the sequential plantings of pak-chai combined with several factors in Cambodia; but the experimental design seemed incomplete.) We suggest that teams that are heavy in one area of expertise (e.g., production, postharvest, or social sciences) should be certain to cooperate with individuals with expertise in other fields such as experimental design and statistics, especially if experiments in these other areas of expertise are going to be conducted as part of the project. (Trexler's team seems to be strongest in the social sciences, and appears to be conducting those types of studies scientifically) Such combination should ensure optimal attention to good experimental design, a high probability for capturing meaningful quantitative results, meaningful interpretation of outcomes and a good possibility that these results could be published in a scientific journal.

2. *Is the approved research program funded appropriately? What should be changed?*

As the Horticulture Innovation Lab has existed until now, we believe the mix of short- and long-term projects, Regional Centers of Innovation, and Trellis Projects have been funded as appropriately as was feasible with the overall funding available to the ME. The EET initially questioned the limited funds provided to the Regional Centers of Innovation, but upon realizing that these were somewhat virtual/conceptual Centers and were part of existing institutional facilities, the starting awards seemed more appropriate. We also recognize that these Centers should act as focal points to bring in additional funds from other partners.

We noted that the funding for Trellis Projects was quite small, but again, in light of the overall Horticulture Innovation Lab budget, these seemed appropriate as capacity building efforts (both for HC and US participants) and also to extend the visibility of the Horticulture Innovation Lab in Feed the Future countries.

Several HC participants also informed us that they believed they did not have adequate funding to complete their stated objectives. This information came to us from the Survey Questionnaire directed towards the HC investigators (see Appendix 3). We did not receive confirmation from all US PIs that they agreed with this assessment by the HC team members; however, some US PIs indicated that their HC partners had not submitted adequate initial budget requests. During our evaluation, the EET was unable to get a firm grip on the level of oversight in budget setting, either by the PIs or the ME (as a second level of review). It appeared that HC budgets were the responsibility of the US PIs. We suggest that for future projects, the ME might need to take a more active role in reviewing and evaluating each project's budget line items before final approval, in order to ensure ample funding is in place for all proposed facets of the project activities. We also suggest that the funding framework adopted by Steve Weller, PI (CP, Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers) be considered by other PIs. In this Project the PI held some of the total funds back, in order to serve as a back-up to provide additional support to those HC members who had initially under budgeted but were showing good progress on their objectives. Some of these reserve funds were also being used for travel and meeting attendance by HC participants, but with Steve reviewing and approving these on a case-by-case basis.

3. *What have been the significant accomplishments in terms of research and technology dissemination?*

   Notable accomplishments related to dissemination include the various projects that incorporated some element of farmer-focused or train-the-trainer workshop or training activities in production or postharvest practices. On the production side, these include:

   - Seed/seedling production training in Central America (*Semillas de Esperanza*: Vegetable Seeds for Sustainable Agriculture; Nienhuis, PI)
   - Use of insect-exclusion netting or high tunnels in Africa (Low Cost Pest Exclusion and Microclimate Modification Technologies for Small-Scale Vegetable Growers in East and West Africa; Ngouajio, PI)
   - Sustainable Development of Horticultural Crops in Zambia for Food Security, Income Generation and in Support of the Tourism Trade; Simon, PI
   - Use of EM and EMINA to produce bio-fertilizer, bio-insecticide and the bio-compost for safe vegetable production in Vietnam. Women dominate in the production of vegetables in the communes and some of the trained women have become entrepreneurs in producing and marketing the above products to other farmers. Other women farmers produce and sell grafted seedlings to other farmers (Safe Vegetable Production in Cambodia and Vietnam; Trexler, PI)
   - Ground-breaking research on the field agronomy of African indigenous vegetables (Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers; Weller, PI)

   On the postharvest side, these include:

   - the development of a postharvest extension program in Southeast Asia (Integrated Postharvest Extension Program for Cambodia and Vietnam; Paull, PI),
   - food safety educational messaging in Central America (Delivering Vegetable Safety Education Through Established Social Networks in Latin America; LeJeune, PI),
   - the creation of a postharvest training and service center for Africa (Extension of Appropriate Postharvest Technology in Sub-Saharan Africa: A Postharvest Training and Services Center; Barrett, PI).
   - pioneering research on the nutritional quality of African indigenous vegetables (Sustainable African Indigenous Vegetable Production and

Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers; Weller, PI)

All the above projects, and others not noted here that included training components, have demonstrated that significant numbers of farmers or marketers can be reached through the Horticulture Innovation Lab activities. Of particular note is the train the trainer activity in the Barrett project, for which 36 postharvest "master trainers" from seven African countries have completed a one-year long training program. These individuals are now back in their home countries and many are in the process of setting up their own, local training facilities, as well as serving as master trainers for groups of farmers in their own countries.

Other accomplishments to mention are the seed drying technologies being studied and developed to improve and extend the storage of quality vegetable seeds in Southeast Asia (CP, Seed Systems – Improving Seed Quality for Smallholders; Bradford, PI) and the dissemination potential of the RICs. The seed project has shown dramatic increases in seed viability for production purposes, but also shows potential for use in seed storage of seed foods. Seed drying with the beads also protects the seeds from mold infection and weevil infestation as well as aflatoxin buildup. The establishment of the Regional Centers of Innovation is viewed as a significant step forward in building the infrastructure for further dissemination of outputs from the Horticulture Innovation Lab, as well as those of other partner organizations.

4. *Among the projects making significant progress, which ones are scalable for a greater impact?*

   We believe the following projects are probably closest to scale up: Seed Systems – Improving Seed Quality for Smallholders (Bradford, PI) and Extension of Appropriate Postharvest Technology in Sub-Saharan Africa: A Postharvest Training and Services Center (Barrett, PI). The seed drying technology, with private partner input (Rhino Research, Thailand) could easily be expanded to other parts of the world for seed quality applications in vegetable crops, and with some additional technological development, could also show spill over value in seed storage applications of staple crops (cereals and grain legumes). The Postharvest Training and Services Center concept and model, with the involvement of master trainers, should be replicated throughout the Feed the Future countries where vegetable production is a significant component of the agricultural sector.

5. *What activities have not been as successful as planned and why?*

   As noted earlier, the Horticulture Innovation Lab is still a young program, with several mid- to long-term projects ongoing. The EET found it difficult to determine the overall success of these active projects at this point in time. The

EET thus looked at the earlier IIPs and EPs to gauge their success. We noted that the IIPs had varying levels of success in meeting the stated objectives in full, with our belief that often any lack of full success was due to the one-year time frame of these projects. Issues with the release of funds, especially to HC partner institutions, reduced available project time even further in some cases. We believe these problems could be overcome in the future by having projects that are set up for a minimum of two years. Nonetheless, even for IIPs that did not complete their objectives as fully as the team had hoped, we believe that all the IIPs were successful from the standpoint of identifying a wide range of partners for future projects and providing good exposure for the Horticulture Innovation Lab in a large number of public and private institutions of host countries in Africa, SE Asia and LAC and the US.

The EET had some discussions about the perceived success of the floriculture project, Building an Ornamental Industry in Honduras (Bennett, PI). On one hand this project could be considered unsuccessful as it appears that the market, infrastructure and policy constraints were too high to enable an effective floriculture market in Honduras. However, we also believe that identifying these constraints was a very successful outcome, as the information will inform future efforts on this topic in Honduras.

The one project noted as unsuccessful was the EP, Market Oriented Sustainable Peri-Urban and Urban Garden Cropping System: A Model for Women Farmers in Thailand, Cambodia and Vietnam. The problem here was apparently a lack of action by the PI. The ME made every effort to keep the project alive. However, due to lack of response from the PI, the ME rightfully terminated this project at an early stage.

6. *In what ways are the research activities strategically sequenced to ensure targeted development outcomes within a known period?*

The ME has utilized a very interesting structure in the progression of short-term to longer-term projects, which we believe has served the Horticulture Innovation Lab quite well. The initial short-term IIPs enabled the Horticulture Innovation Lab to bring together a broad array of adaptive research and development topics and a large number of partners and to quickly assess a number of topics. This allowed all partners to assess the abilities and commitment of each other. It also provided access to networks of other potential cooperators in HC institutions, and facilitated the gathering of preliminary results that could demonstrate the feasibility of moving forward with longer-term projects. The EPs continued this process of evaluation, and then the PP and Continuation Projects served to move a limited number of these early project concepts on to longer-term status. In addition, the regrouping of some of the Horticulture Innovation Lab participants into new teams for these mid- and longer-term projects was notable as a positive outcome of the succession of projects. Similarly, the CPs also brought different team members and a broader range of activities to bear on more refined questions.

7. *How does the ME ensure that research activities or themes supplement and not duplicate other development initiatives in the regions where the Innovation Lab is active?*

   Our discussions with the ME indicated that they are using several resources to assess potential overlap with other regional projects and initiatives. The ME is talking with existing HC partners that are part of the Horticulture Innovation Lab The broad range of individuals brought into the Horticulture Innovation Lab through various short- and long-term projects has proven very beneficial in having contacts throughout the regions where the Horticulture Innovation Lab is active. Secondly, the ME has members on the IAB as additional eyes and ears with respect to pre-existing or ongoing regional activities. Several on the IAB have large networks of colleagues in the horticultural research and private sector arenas, so we presume they would be able to provide good guidance on this issue to the ME. Thirdly, The ME and all the Horticulture Innovation Lab partners are in contact with USAID Mission staff in HCs. These contacts should also be counseling the ME on overlap potential, as the Missions gain an understanding of what the Horticulture Innovation Lab is planning. Lastly, we note that in the future, the partnerships developed through the Regional Centers of Innovation should provide another level of information on existing or planned regional activities. The Director of the Horticulture Innovation Lab, Dr. Elizabeth Mitcham is also the Chair of the USAID Feed the Future Innovation Lab Council, and she should be able to get firsthand information on all related activities in all the ten Innovation Labs. The ME may like to carefully monitor the research plan and activities of the closely related IPM and Nutrition Innovation Labs and the activities of the in-country Missions so that the Horticulture Innovation Lab projects supplement and complement their activities.

8. *Do research goals have national policy implications? If so, how are they addressed? Give examples.*

   The strongest components within the Horticulture Innovation Lab that would have relevance to national policy issues are those in the areas of food safety and human nutrition and health. Several projects have focused on establishing production practices that would minimize pesticide use (e.g., Low Cost Pest Exclusion and Microclimate Modification Technologies for Small-Scale Vegetable Growers in East and West Africa; Ngouajio, PI; Sustainable Development of Horticultural Crops in Zambia for Food Security, Income Generation and in Support of the Tourism Trade; Simon, PI) or would help growers monitor food safety parameters (Delivering Vegetable Safety Education Through Established Social Networks in Latin America; LeJeune, PI). As these projects mature and more growers can produce pesticide-free products (e.g., with netting technologies), or at least have used sufficiently low levels of pesticides such that harvested products can be certified below maximum residual levels (MRL) of acceptability, then possibilities will increase for export opportunities. This may require national governments to develop or update guidelines for monitoring food safety standards, such that these export chains can flourish.

With respect to nutritional issues, as more information is gathered on the nutritional quality of indigenous or traditional fruits and vegetables (e.g., Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers; Weller, PI), especially with respect to micronutrient minerals and vitamins, opportunities will grow for policymakers to develop strategies for promoting the consumption of these nutritious horticultural products. Furthermore, policy changes may be needed to help create more markets for their sales, especially in nutritionally at-risk population centers. The projects within the Horticulture Innovation Lab should continue to analyze the nutritional quality of generated food products, especially in response to the use of differing production or postharvest technologies, and should ensure that this information is available to policymakers.

9. *What was the process for sub-award selection? How effectively did the process yield a high quality, relevant portfolio of activities?*

   It appears that initial sub-awards for the IIPs came, in many cases, from pre-existing cooperation and collaborations amongst some of the US PIs and HC partners. The IIPs served as a platform for all the Horticulture Innovation Lab participants to assess the potential contributions of other partners, and to use this network to identify other partners who were needed for specific aspects of later projects. Prior history with these partners appears to be the basis for sub-award selection in later mid- and longer-term projects. It is notable that many of the early partners were incorporated into later projects. In some cases, new team groupings were developed, presumably thanks to this earlier contact on the Horticulture Innovation Lab through annual meetings and other outlets. Some of the IIPs, such as the African Indigenous Vegetables, when applying for the second round PP, failed to meet the standards and were not approved. However, in the case of the African Indigenous Vegetables Project, the PI and the cooperating scientists and partners did not give up. They pursued their interests and competed for the bigger CP and succeeded in getting the approval of the review team and the ME and the project was awarded. Therefore, the ME carefully reviewed the projects and the sub-awards before approving them. In fact, it appears that all approved projects were selected on scientific merit, their focus to address priority objectives, their likelihood of success, and the merits of the expected outputs to address the Feed the Future objectives. The EET feels that this process was sound, and did yield a strong portfolio of activities.

10. *Assess the balance of domestic versus overseas research in terms of effectiveness of solving constraints in developing countries. Are changes needed in the balance?*

The EET believes the balance of domestic versus overseas research is quite appropriate in the Horticulture Innovation Lab. We noted that most of the US partners were actively engaged with HC partners. They were visiting HC partners and institutions on a regular basis, and were providing input for activities in overseas locations. The apportionment of funds for domestic versus overseas activities was also good. We noted that some activities were brought to the domestic side when progress was lacking on the overseas end, due to constraints with facilities, resources or personnel. This helped to move these projects along. One example of this is the CP "Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers" (Stephen Weller, PI), where the nutritional analyses of vegetables and some of the analytical methods development were moved to the US institutions, to ensure that the project stayed on course.

The EET found no need to recommend a change in the current balance of activities between domestic and overseas participants.

11. *How has the United States benefited from the Innovation Lab's research? Give examples.*

The Horticulture Innovation Lab research activities have provided a number of benefits to the US. Projects dealing with indigenous vegetables have provided access to new indigenous vegetable germplasm for potential new crops in the US. The research on seed drying technologies with zeolite beads has provided good general knowledge on seed quality issues that are pertinent to US seed companies. Exposure to this technology could lead to new products or procedures for US seed companies and horticulture related industries. Much of the market value chain research that ends up in scientific publications will provide new information for social scientists on the functioning of unique market situations; this should be good general knowledge about the functioning of agricultural markets that could be used in some smaller market settings within the US. Additionally, the Trellis Projects provide a valuable experience for US students, allowing them the opportunity to gain exposure to international development and unique foreign cultures in agricultural settings. Furthermore, all of the interactions between US universities, students, or professors, with their counterparts overseas, will help to establish long-lasting research networks for future collaborations.

12. *How much emphasis should occur within the Innovation Lab portfolio on basic research, applied research, implementation, and human and institutional capacity building?*

The EET assessed the current distribution of effort within the Horticulture Innovation Lab of 20%, 40%, 20%, and 20% for basic research, applied research, implementation, and human and institutional capacity building, respectively. We believe this is a good distribution of effort, and the ME should strive to keep this balance in the future or slightly increase the implementation and human and institutional capacity building. The EET recognizes the need for some basic research to identify new approaches to address the production, postharvest, and food safety objectives, but also notes that many good approaches are currently available, and they could be tested through applied research in new environments within Feed the Future countries. Implementation efforts should continue to constitute a significant portion of the Horticulture Innovation Lab portfolio.

Recommendation 6. We recommend that training efforts and appropriate workshops are built-in as an integral component of most, if not all future projects, as this will facilitate both implementation and capacity building objectives.

13. *How does the Innovation Lab respond to the Title XII "Famine Prevention and Freedom from Hunger" Amendment to the Foreign Assistance Act of 1961?*[1]

    Title XII, "Famine Prevention and Freedom from Hunger," of the Foreign Assistance Act of 1961, as amended, states that the principles of the "land grant model" will be used for improving food production and agricultural development. Title XII activities must be carried out, insofar as possible and appropriate, by Title XII institutions, with any additional non-Title XII resources as may be needed, under sub-agreements. Missions must identify Title XII activities at an early stage in the development of a planned results framework. The Horticulture Innovation Lab has responded to this Act by enlisting the assistance of investigators from a number of land grant institutions (e.g., University of California, Davis, Purdue University, The Ohio State University, Rutgers University, University of Wisconsin, University of Hawaii, Cornell University, Michigan State University and others). The ME has also conversed with Mission staff on their ongoing activities throughout the life of this project.

V. Alignment with Feed the Future Research Priorities

1. How has the Innovation Lab aligned with Feed the Future research and development priorities? Give examples. In what areas has the Innovation Lab not aligned with Feed the Future priorities and why?

   The Horticulture Innovation Lab has done a very good job of reacting to Feed the Future priorities, especially in light of the fact that these priorities were thrust upon them in mid-course, at an early stage of this Innovation Lab's lifetime. The ME has been attentive to directing their efforts towards Feed the Future focus

[1] http://www.aplu.org/page.aspx?pid=587

countries. The Horticulture Innovation Lab has addressed the three Feed the Future research priorities in the following ways:

(1) Advancing the Productivity Frontier. The Immediate Impact Project (IIP): Sustainable Production and Marketing of Vegetables in Central America (Nienhuis, PI) tested a broad range of tomato germplasm to help identify varieties that were productive in local environments within Honduras, Guatemala, Nicaragua, and El Salvador. The IIP: Indigenous African Leafy Vegetables (ALV) for Enhancing Livelihood Security of Smallholder Farmers in Kenya (Weller and Marshall, CO-PIs) has similarly assessed the productivity of different cultivars of plants, in this case amaranth, African nightshade, and spider plant (33 cultivars in total, over two seasons). Also, the IIP: Deployment of Rapid Diagnostic Tools for Phytophthora on Horticultural Crops in Central America (Ristaino, PI) used morphological and molecular tools to conduct field surveys to identify the major *Phytophthora* species (plant pathogens) responsible for production losses in several horticultural and floriculture crops. It should be noted that these one-year projects provided good data that was leveraged for subsequent longer-term projects.

(2) Transforming Key Production Systems. Several projects focusing on postharvest issues, including those that tested available technologies or emphasized training, are good examples of how the Horticulture Innovation Lab addressed this Feed the Future priority. The IIP: Biologically Based Postharvest Quality Maintenance and Disease Control for Mango and Papaya (Paull, PI) used controlled experiments and technology transfer (train-the-trainer workshops) to assess the effectiveness of coatings and essential oils, as alternatives to fungicides, in the control of postharvest diseases in mango and papaya. The Long-Term Pilot Project (PP): Increasing the Capacity of Smallholder Farmers to Produce and Market Vegetable Crops in Uganda and the Democratic Republic of the Congo (Scow, PI) is developing a participatory extension model to enhance marketing and production of horticultural crops by linking the Farmer Field School (FFS) method with the Participatory Market Chain approach; is researching and developing integrated soil fertility management practices for tomatoes and indigenous leafy vegetables; and through their training of facilitators for the FFS, is helping to expand the region's capacity in research, education, and extension. As another example, the Long-Term PP: Safe Vegetable Production in Cambodia and Vietnam: Developing the HARE-Network to Enhance Farmer Income, Health, and the Local Environment (Trexler, PI) is using a participatory approach, with the help of local universities, to teach improved technologies for better horticultural production, postharvest quality, and food safety to smallholder farmers (mostly women), and to expand their knowledge in marketing as a means to gain more income. Also, the CP: Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers (Weller, PI) is assessing diverse germplasm, various

fertilization strategies, insect pests, and several agronomic characteristics to help develop and transform African indigenous vegetable production.

(3) Enhancing Nutrition and Food Safety. All of the projects, being in one way or another focused on postharvest quality, are directly or indirectly realizing impact in the areas of nutrition and food safety. One example is the Continuation Project: Sustainable Technology for Orange and Purple Sweet potato (STOPS) in Ghana (Bonsi, PI), which is using GAP and decision analysis tools to strengthen the value chain in three sweet potato growing regions in Ghana, in order to improve food security, agricultural productivity and economic value; and to increase the consumption of foods high in pro-vitamin A and antioxidants for good health. Another example is the Continuation Project: Delivering Vegetable Safety Education through Established Social Networks in Latin America (LeJeune, PI), which is using participatory research and outreach activities to reduce food contamination, improve farmer health and produce quality, open new markets for the sale of safe produce, and to deliver additional nutritional education to farmers. Also, the CP: Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers (Weller, PI) is assessing the nutritional quality of various indigenous or traditional vegetables, especially with respect to micronutrient minerals and vitamins.

As to areas within this Horticulture Innovation Lab that are not aligned with Feed the Future priorities, we have looked closely at all the projects, but can find none that fall outside the scope of Feed the Future. The ME appears to have been very attentive to this. We also believe that the nature of this Horticulture Innovation Lab, being focused on nutritious, horticultural crops and postharvest processes, allows it to fit nicely within the Feed the Future framework.

2. *How well do the Innovation Lab research and capacity building activities fit under one or more of the seven programs of the Feed the Future Food Security Innovation Center? What are the relevant program areas? How can this fit be improved?*

The seven programs of the Feed the Future Food Security Innovation Center are the following:

1) Increase cereal yields and adapt to climate change
2) Increase productivity and availability of legumes
3) Protect animals and tropical staples from major pests and diseases
4) Sustainably increase production and consumption of highly nutritious foods and diversify diets
5) Fundamentally transform key production systems
6) Create supportive agricultural policy environments and
7) Professional and organizational capacities are inadequate to address agricultural challenges and opportunities.

The Horticulture Innovation Lab addresses two of these program areas quite nicely: (4) Sustainably increase production and consumption of highly nutritious foods and diversify diets and (5) Fundamentally transform key production systems, through its efforts to increase the production of safe horticultural food crops and to increase market opportunities for these foods. We believe that if the Horticulture Innovation Lab stays on their current course of projects, they will continue to firmly contribute to these two program areas. In addition, through the three recently created Regional Centers of Innovation (in Southeast Asia, Africa, and Central America) the Horticulture Innovation Lab has the opportunity to contribute to program areas (7) Professional and organizational capacities are inadequate to address agricultural challenges and opportunities, and perhaps to program area (6) Create supportive agricultural policy environments. These Regional Centers of Innovation are just getting started, so there is little track record to draw upon. However, we believe the potential is there and improvements can be made through the Regional Centers of Innovation which can act as the focal points for establishing strong collaborations with local private industries, government entities, USAID Mission Offices, and others, to help cultivate professional and organizational capacity in these regions and to help policymakers develop governance and regulations that will increase market opportunities for smallholder farmers.

VI. Human and Institutional Capacity Building

1. *How has the Innovation Lab been effective at building the capacity of host country researchers, policymakers and practitioners?*

The Horticulture Innovation Lab has funded 15 US partners and has worked in 14 (of 19) Feed the Future countries. The range of IIP, EP, PP, CP projects and other activities have reached or affected more than 18,500 individuals since the Horticulture Innovation Lab commenced in 2009. About 87 individuals or organizations have been involved actively as co-investigators or collaborators in Horticulture Innovation Lab projects since 2009 (Table 1; next page). The majority of these (68%) have been individuals at universities and/or research institutions, but there are a growing number of private sector firms becoming involved particularly in assisting with provision of new technologies with potential use in horticulture production and postharvest systems. A full list of all PIs, partners and collaborators can be found in Appendix 8.

It was interesting for the EET to observe the enthusiasm with which local PIs interacted with the US PIs. Clearly there was a great deal of mutual respect and confidence in the ability of partners to undertake responsibilities for their parts of programs. There are certainly personal and professional benefits to be achieved by being involved in such programs.

Table 1. Number of co-principal investigators or collaborators from different regions of the world that have been involved in Horticulture Innovation Lab projects since 2009.

Region	*Number of collaborators	No. in universities or research organizations	No. in NGOs
Africa	43	28	15
SE Asia	19	14	5
Latin America and Caribbean	16	12	4
Europe and US	9	5	4
Total	**87**	**59**	**28**

* This list includes people or organizations that have been either co-principal investigators or collaborators in an Horticulture Innovation Lab project to date. A total list would also include numerous farmer leaders involved beyond the organizations counted here.

Regrettably, we were not able to ascertain the influence of the Horticulture Innovation Lab on policymakers within host countries. One exception to this was with Dr. Stephen Mbithi, CEO of Fresh Produce Export Association of Africa (FPEAK) in Kenya as well as on the Board of the Kenyan Horticultural Council and the Horticulture Council of Africa (HCA). FPEAK is a serious and committed partner to the Regional Center of Innovation, Thika, Nairobi. His organization plays a very important role and is a strong advocate of horticultural growth for African countries facilitating horticultural exports from Kenya. Horticultural exports are very important sources of overseas funds for Kenya; Mbithi firmly believes that other neighboring countries have the potential to be similar to Kenya once appropriate infrastructure and policies have been developed. FPEAK is strongly and publicly supportive of the work of the Horticulture Innovation Lab. Dr. Mbithi would like to see Horticulture Innovation Lab increase its efforts in undertaking appropriate research, especially for the fruit industry, which together with flowers, is the main export earner. He has a strong belief that the Horticulture Innovation Lab will be able to make significant innovative inputs to horticultural producers in the future directed towards assisting the smallholder farmer to reduce costs of production and to reduce postharvest losses and wastage. Mbithi wants to see much more interaction between the private and public sector research and development communities (including Horticulture Innovation Lab) and would welcome opportunities for further collaboration.

The Horticulture Innovation Lab has actively encouraged development of grower associations and cooperatives within and between regions, and facilitated the training of these groups. Regular meetings have promoted effective transfer of knowledge and experience among groups. In some regions, women-only groups have been engaged to ensure active participation by and empowerment of women. Several projects include 'train-the-trainers' programs that allow the knowledge to be extended to many more individuals. The trainers are encouraged to be champions of their topic in their areas, meeting regularly with other members and faculty and particularly with local extension agents and NGOs to share knowledge and experience within and across regions. The postharvest training of the trainers project at the Postharvest Training Services Center at AVRDC in Arusha, Tanzania (Barrett, PI) is an excellent example of this accomplishment.

While the majority of collaborative efforts have been made with faculty at universities, a number of projects do include individuals from local extension services and NGOs. This is particularly so in the Trellis Fund projects; in 2013 it appears that the majority of host organizations are NGOs working with smallholder farmers and particularly women's groups. The relationships that emerge from these Trellis Fund projects are mutually beneficial to all concerned: the smallholders are exposed to current thinking on agricultural production and postharvest systems, the NGOs benefit from the relationship by having more 'hands' available to carry out specific projects and the students benefit by gaining real life experience in development activities in a foreign country – very useful also for future CVs. Successful students are chosen carefully by the ME to match the best applicants for specific projects. To date this has been very successful.

2. *How has a pipeline of students been cultivated for long-term degree training opportunities?*

The pipeline for education and training students is being cultivated. To date at least 108 students have been involved in Horticulture Innovation Lab projects (Table 2). Of these, 29 received full funding while others received partial funding. About 58% of these students were female. For the advanced degrees (Masters and PhDs), 62% of the candidates were female.

Table 2. Number of students trained with partial or full Horticulture Innovation Lab funding through 2012.

Degree studied	Female number	Male number	Total	Percentage
Bachelor	25	22	47	43.5
Masters	29	15	44	40.7
PhD	9	8	17	15.7
Total	**63 (58.3%)**	**45 (41.7%)**	**108**	

Forty-two (39%) of the students were trained in the US and more than 65% of students were educated in host countries. At the PhD level, ten students were educated in the US and seven were educated in host countries. Many BS and MS students work on specific projects with the Horticulture Innovation Lab. For example, one of the undergraduate classes at RUA in Phnom Penh was involved in assisting with baseline surveys for the Savings Led Microfinance project (Miller, PI), while other students were involved in analyses of soil physical, nutrient and microbial attributes in the Safe Vegetable Production project (Trexler, PI). Such experience will be invaluable in future as these students will have gained experience and skills in basic experimental design, interacting with people, collecting and helping with analysis and interpretation of data, as well as gaining confidence in working with PIs from different countries.

Fig. 3. Graduate students from RUA, Phnom Penh collecting soil samples.

The EET believes that there will be a need for an increased number of MS students in host countries as the new technologies and management practices are proven and adopted and as horticulture becomes more important economically. The US PIs could and should be active members of their advisory committees. For long-term sustainability there is a need for a greater number of host country students to have the opportunity to undertake their full PhDs in the US, or alternatively, be funded for postdoctoral studies after they have graduated at home. It is possible to establish 'sandwich' PhD programs whereby the students spend the first part of the program in the US, return to their home country for research on local problems – specifically associated with Horticulture Innovation Lab projects – and then return to the US for the final stages of the degree process. In-country university faculty would be co-supervisors in this process and would visit the US at least once during the tenure of the student in the US. This exposure to the US academic and scientific environment is highly desirable to develop personal and professional confidence as well as to establish extensive networks that will be invaluable on the students' return to their home countries.

One of the issues confronting graduates in some Feed the Future countries is the lack of job opportunities after graduation. This applies particularly, but not exclusively for BS graduates who often find it impossible to get adequately paying jobs in some countries (such as Cambodia). With the changes in curricula that are being planned in SE Asia and in some African countries such as Kenya, it is hoped that the quality of BS graduates will improve and that they will have the skills and abilities desired by employers. In their interaction with any private sector partners, PIs should endeavor to get them to employ such students during school vacations in order to get to know the students and to give them some real world work experience.

3. *Has the program been successful in selecting the right mix of students from appropriate institutions? Are these trained students returning to their home countries to continue work in their trained fields?*

It is too early to be fully confident about answering this question. Horticulture Innovation Lab funds supported more than 30 university students through 2012. Students are selected on a competitive basis by the PIs, the host institutions and/or the Horticulture Innovation Lab and thus are top students meeting specific criteria required for entry into programs. No host country PhD students have graduated to date.

Six scientists from universities in Vietnam and Cambodia were mentored for one year and received extensive postharvest training at short courses held at both University of Hawaii at Manoa and University of California, Davis. One of these has benefitted from the information and information sources (including postharvest texts and product pamphlets) that she was able to obtain during this experience. She has been using this material to upgrade and modify her lecture notes for both undergraduate and postgraduate lecturing at Hanoi Agricultural University. This will enhance the quality of teaching. Five scientists from Benin went to attend a short course at MSU in relation to the Agronet pest exclusion project (Ngouajio, PI) and they benefitted greatly from interaction and networking with a range of faculty and other attendees.

The Trellis project has been very successful in providing small-scale, in-country development organizations access to US graduate student expertise, with benefit to both. The Horticultural Innovation Lab has funded two rounds of Trellis Fund projects through 2012, for a total of 24 projects. A further round has been called for in 2013 and is in the process of being finalized. In the first completed round of Trellis projects, 10 organizations working with 10 graduate students produced 124 training and extension meetings, 1,935 farmer participants (including 1,492 female farmers trained), and 10 demonstration plots. The 2013 round was extended to a wider range of NGOs and the response has been excellent; more than 150 applications were received and from these a tentative decision has been made to award 13, in eight countries with the likelihood that 10 will be awarded to NGOs, two to universities and one to a government research institute. There is real potential in extending this scheme to allow some host country graduate students to obtain work experience on selected US farms where they would have the opportunity to gain knowledge and experience in innovative production, postharvest and/or marketing (supply chain) systems. There is great value in this Trellis scheme; for very little money (~$4,500 per project, $2,000 for the host organization and the rest to cover student airfares and subsistence) it introduces keen motivated young people who have demonstrated an interest in international agricultural development to become familiar with a new country, gain valuable experience and bring their expertise to bear on solving real problems with committed organizations working with small farmers. The young people involved in this scheme will undoubtedly be valuable for the USAID Feed the Future program in the future.

Fig. 4. Dr. Johnson Odera (ATRC) and Dr. Michael Grusak (EET) in ATRC.

Because of the newness of this Horticulture Innovation Lab it is too early to determine if all students educated in the USA will return home to meaningful employment. However there is no evidence available to indicate that they will not. The resurgence of horticulture in many countries and the increasing emphasis by governments to increase agricultural education spending up to 10% of GDP heralds promise for changes at the tertiary level that hopefully will increase employment opportunities. One notable example of a returning graduate student is Dr. Johnston Odera, African Technical Research Centre (ATRC) in Arusha, Tanzania – a research and development unit of Vector Health International. [Vector Health International is a joint venture of Sumitomo Chemical Co. (Japan) and A to Z Textile Mills (Tanzania)]. Dr. Odera did his PhD at Iowa State University, postdoc in the US, and then returned to Tanzania where he now holds this very responsible position leading agronomic research involving agronets and agro shades for pest exclusion and possible pest deterrence.

4. *Compared to the research activities, what has been the level of effort and investment in training and institutional capacity building? Is it sufficient?*

The level of investment in training for human capacity development has been appropriate considering the comparative 'youth' of the Horticultural Innovation Lab compared with other similar organizations. The balance between research and training has been appropriate with many local students at the bachelor and masters levels having good opportunities to interact with the projects by obtaining information and data from the field experiments for their own practical reports and dissertations. Because of the potential need for an increased supply of MS graduates in Feed the Future countries, the ME and any new PIs are encouraged to include this component in their proposals.

When in-country PIs are energized and mentored whilst undertaking Horticulture Innovation Laboratory research projects, they become better faculty members gaining confidence and ultimately having the capability to take increasingly responsible roles within their own institutions. The EET was not able to obtain factual data on progress made in institutional capacity building by the Horticultural Innovation Lab. It is also hoped that any new postgraduates who are involved in Horticultural Innovation Lab projects will return to secure positions in universities and/or polytechnics thus strengthening the teaching and research capacities of those institutions.

The creation of the Regional Centers of Innovation in three separate regions surrounded by Feed the Future countries has been successful to date and will open doors, as the Regional Centers of Innovation will serve as hubs for further institutional capacity building. These will involve in-country partners and collaborators and provide an ideal opportunity for further exposure and contributions to Horticultural Innovation Lab and national programs. This will enhance institutional capability as personnel in the host, and other, institutions work together in introducing, demonstrating and promoting new technologies for horticulture as well as organizing and implementing training programs for local and regional participants.

The establishment of the Postharvest Training and Services Center was an impressive example of institutional capacity building. This facility has been used on several occasions since it was established in 2012 with training programs being delivered originally by US PIs but now being organized and run by local partners and collaborators. The scale up following the original postharvest training project (Barrett, PI) was impressive with a large multiplier effect occurring in seven countries following the one-year advanced training program that was undertaken by 36 trainers through the Postharvest Training and Services Center (PTSC) at Arusha. It is estimated that the solid and updated training that these individuals received has impacted their normal professional programs of work in their institutions and influenced a large number of smallholder farmers mostly women. It also enabled professional enhancement and capability of the institutions that had been lacking hitherto. The intention of the PIs was to replicate such PTSCs in different countries so that local training can be undertaken without the expenses involved in transport and accommodation for courses to be held in one central location. The EET strongly endorses this proposition.

Recommendation 7. We recommend that the Horticultural Innovation Lab, in conjunction with in-country collaborators, extend the postharvest training program, so successful in Tanzania, into other Feed the Future countries using the Regional Centers of Innovation as a base and that the Regional Centers of Innovation be equipped appropriately to enable this to occur.

5. *Should there be greater focus on institutional capacity building? If so, in what areas?*

   The EET suggests that there should be a slightly increased emphasis on institutional capacity building during the second phase. This should not be a dominating theme as the Horticultural Innovation Lab will not be able to afford any large programs and it is recognized that other educational development programs exist within USAID and other international and national agencies. However, training and mentoring of local faculty should continue as has occurred in the past four years.

   The EET recognizes that there are numerous efforts on agricultural/horticultural educational development being undertaken by a number of international agencies, NGOs and national governments to improve the access to and standards of education in general. However, in the course of our study we did not come across details of any of these. The ME should become aware of these efforts with a view toward seeing if they can complement or add to existing Horticultural Innovation Lab projects. There is no doubt that a small agency such as the Horticulture Innovation Lab cannot afford to become sidetracked from its main goals and hope to have a major impact on widespread institutional capacity building. Notwithstanding this, there are some topics that could be addressed by the Horticultural Innovation Lab in their efforts to increase institutional capacity in Feed the Future countries:

   a. Assist in efforts to remodel, modernize and enhance the curricula involved in tertiary horticultural education. Localized attempts are undertaken at several universities and there could be real benefit in working with host universities in all major focus regions of the Horticultural Innovation Lab (Central Africa, SE Asia and Central America) to establish some uniformity (but not duplication) across the undergraduate and postgraduate curricula.
   b. A suggestion has been made that agricultural universities in South and East Asian countries could join together to form a Masters program similar to the one that exists in Europe that enables students to undertake specific courses in different universities during the study for their degree. It is possible that US horticulturalists or program specialists could assist in formulating this process, perhaps through an Horticultural Innovation Lab initiative.
   c. In addition, there are opportunities to arrange local or regional workshops that could organize hands-on experiential activities related to topics such as preparation of research proposals, how to write a scientific paper, how to write a paper to get it accepted into a high impact journals and how to prepare a targeted curriculum vitae. Recently an international group organized a workshop on these topics in Thailand. Initially, there were 20 enrolments from staff at a local university, but when the course commenced about 75 people turned up. Subsequently, there was a demand for more such courses to be held in different parts of Thailand. In addition, workshops

could be organized on how to set up, implement, and analyze data from an 'ideal' experiment to obtain optimal results.

d. The Horticultural Innovation Lab should work closely with other international agencies including FAO, World Bank, the Asian Development Bank, the Technical Centre for Agricultural and Rural Cooperation ACP-EU [CTA], CIRAD and with USAID to provide funding for selected graduate students and/or faculty members to attend selected international symposia, congresses and/or training workshops on specific subjects of value personally and institutionally.
e. Increase South to South exchanges enabling junior and mid-rank faculty to spend short-term visiting appointments at institutions or NGOs in other regions to learn of different approaches to adaptive research to create horticulture production and postharvest management packages that include innovative technologies, to establish personal linkages, to see other countries that may be more or less advanced than their own. They should then return to their own institutions with a renewed sense of urgency and commitment that would, hopefully, be of benefit to their colleagues as well. This could be a competitive project with the best proposals (maybe five per year) getting the prize visits.
f. The Horticultural Innovation Lab, together with USAID, should sponsor selected individuals to attend relevant international workshops especially if they are organized in conjunction with an international conference. The International Society for Horticultural Science (ISHS) is organizing several training workshops, workshops and seminars to be held within the International Horticultural Congress, August 2014 in Brisbane, Australia.

6. *How can impact of institutional capacity building be captured and measured more effectively?*

The simplest way to measure impact is to have a numerical system that counts numbers above or below an initial baseline. This is essentially what the USAID requires for the Innovation Labs in their annual accounting. Such a system may well include some or all of the following:

Student performance:

- Number of students graduating/passing in year in each degree program as a proportion of those initially enrolling;
- Number of students who graduate as a proportion of those who originally enrolled in each program;
- Number of dissertations (bachelor, masters and PhDs) successfully passed with appropriate honors grades (from none to 3rd, to 2nd to 1st class honors);
- Age/salary distribution of faculty and how this changes with time.

Staff performance:

- Number of refereed papers in international impact factor journals;

- Number of patents applied for;
- Number of publications in non-impact journals such as reviewed conference proceedings;
- Number of invitations to present papers/posters at national and international professional conferences;
- Peer esteem: number of times asked to review manuscripts or to examine masters or PhD theses;
- Number of farmer field days, farmer workshops or seminars organized for local industry (smallholder horticultural farmers);
- Number of times asked to undertake consultancy tasks either locally, nationally or internationally;
- Number and value of external grants obtained for research;
- High rankings for teaching expertise, as ranked by students and by an independent assessment process;

Departmental or university ranking

- Is the vision and mission of the department and university being achieved?
- Number of academic staff with PhDs or masters degrees;
- Number of technical staff with bachelor or masters degrees or technical equivalents;
- Ranking of university in international lists of quality universities (such as the Times Educational Supplement list or US News World's Best Universities);
- Quality of mentoring programs for students in difficulty;
- Proportion of courses/papers that are being taught on-line or by distance education mechanisms;
- Number of faculty that are allowed to undertake sabbatical leave every five to eight years with some funding provided;
- Availability of ready, reliable, consistent, full and free access to the internet for all faculty
- Faculty members have access to their 'own' personal computer (at least there is one in each office);
- Quality and maintenance of buildings, classrooms and laboratories;
- Access to outdoor field laboratories by undergraduate and graduate students for agricultural/horticultural practical studies and experiments.

Once appropriate baselines are established, development of institutional capacity is reflected in gradual and consistent increases in some or all of the above indices. The above points measure numbers; it is a greater challenge to measure sociological improvements (including staff relations; mentoring systems; health provision systems for staff, students; student association systems; number and activity of student teams in sports and cultural activities; cafeterias; sports fields and so on) and the benefits that are likely to follow from students and staff having access to such facilities. In addition, personal aspects (such as confidence, sense of worth, leadership, motivation and commitment) within individuals and departments are more challenging to assess in the short and medium term, but they are very important in building momentum for academic and scientific growth.

Some of the above points may be 'tagged' to Horticultural Innovation Lab activities but essentially any institutional capacity building will be a 'numbers game' involving a relatively small number of students and staff at each institution and the degree of increase in a number of the points above over time.

There is a real need to focus attention on strengthening the ability of host country universities to train future generations of scientists, but given the scarce resources allocated to the Horticultural Innovation Lab and the number of horticultural crops and problems in the sector, it would not be appropriate for a major shift in funding from the Horticultural Innovation Lab to be used in an attempt to embrace major institutional capacity building programs. The best option would be to continue embracing in-country collaborators and partners and involve them fully in proposal generation, research planning, implementation, data collection, analyzing, interpreting, giving workshops and seminars of deliverables and writing up for publication.

VII Collaboration, Outreach and Technology Dissemination

The Horticultural Innovation Lab has an information management team whose goal is to strengthen the capacity of intermediaries to better deliver credible, relevant information to help smallholder horticultural farmers. To achieve this goal the team captures and analyzes outputs of Horticultural Innovation Lab activities, conducts workshops and creates information materials. It provides guidance and develops tools to help Horticultural Innovation Lab projects and the ME to disseminate horticultural information. This team conducts research on the use of extension in horticulture and assesses gaps in information systems worldwide. They have developed several useful tools such as the Global Horticulture Knowledge Bank and a map of horticultural projects worldwide. (Fig. 5; see next page).

The team is working to organize the extension deliverables of Horticultural Innovation Lab projects into useful extension outputs for appropriate use by in-country trainers and farmers. Links were provided to the EET to delve into the Horticultural Innovation Lab Information Management Internal Website (includes information management research on assessing information access gaps). This was very informative, and much of the information would be of interest to PIs. However, it seems that much of it is in a preliminary form and cannot be accessed by external viewers, although quite a lot of the information contained in this internal web site is available in a transformed state on the open Horticultural Innovation Lab web site.

Click and drag map to view project locations in Africa, Asia and Latin America with brief descriptions and links to project pages. Or view Horticulture CRSP Projects within Google Maps.

Fig. 5. Worldwide horticulture projects

Considering the short time that the Horticultural Innovation Lab has been in existence, it has been very successful in making its presence known to the international scientific community. It has a large list of project reviewers from many countries and institutions who obviously became aware of the Horticultural Innovation Lab through contacts with the ME and the proposal reviewing processes. In addition, members of the IAB and the ME have participated and made presentations at national and international conferences about the aims, objectives and accomplishments of the Horticultural Innovation Lab.

1. *What outreach strategies have been integrated into project design to increase likelihood of uptake and utilization of research results? What have been the most effective strategies for outreach at the country level?*

All projects are scrutinized by the ME review panel, which includes Mark Bell, Leader of the Horticultural Innovation LabInformation and Communication Unit, to ensure that they contain appropriate dissemination and outreach components. Critical to this success is the choice of in-country PIs, who have a large responsibility for interacting with farmers, organizing extension events such as farmer field days, and preparing appropriate material containing relevant and useable technical explanations for farmers. PIs are provided with key criteria that are necessary for successful dissemination of information.

The Horticultural Innovation Labhas gained considerable experience about information transfer and dissemination of results since its inception three-and-one-half years ago. They have found that over and over, some key points emerge. For success in information dissemination and extension, the following topics must be addressed in each project and they should be integral to any outreach program:

1. ***Demand driven***. Programs have to be client/needs driven.
2. ***Farmer engagement.*** Farmers need to be engaged from the start from identifying needs through to generating content.
3. ***Credibility of information.*** Ensure credible sources of information and provide validated recommendations.
4. ***Project driver.*** Projects need local champions who will guide, direct and push activities.
5. ***Market and finance access.*** Consider markets and financing as an integral part of extension/outreach. These elements need to be integrated with extension information supply systems for success. Mobile money, for example, is making a range of associated support services more efficient (e.g. input suppliers having inputs more readily available as they are paid more promptly). Market information provides viable outlets for increased produce.
6. ***Trust***. Build trusted "delivery" mechanisms to help people move from accessing information to testing and then adoption.
7. ***Integration.*** Use existing communication channels and where possible, integrate the use of traditional (e.g., field demonstrations) and "new" (e.g., video, radio, cell phones) approaches, like the efforts in Ghana to combine use of cell phones with radio programs. Remember that "seeing is believing."
8. ***Sustainability.*** Sustainability is a major issue for emerging services. For example, it is known that many ICT projects such as those involving Tele-Centers cease as soon as project funding stops. Charging for services is increasing as a means to improve sustainability and to validate service value.
9. ***Input suppliers.*** Input suppliers increasingly appear as promising major players for enhanced information delivery. However a major task will be create an environment for input providers to build trust through providing sound and honest advice and consistent return service. In many countries, there is farmer interest in disease and insect diagnostics, and (sometimes) nutrient problems and understanding their control options.

Regional differences. While radio, cell phone and cinema (use of video) seem very promising across Africa, radio seems to be less used in Asia. Electricity can be an issue, but charging stations may be a potential focal point for information distribution. It appeared that PIs have made little progress toward establishing close links with the different media outlets in host countries in order to ensure that news on successful technical innovation can be highlighted in ways that are readily and immediately available to smallholders and trainers. The exception to this would be the success of Dr. Vong in Hanoi who has established close contact with a local TV company that broadcasts agricultural news and information (Safe Vegetable Production in Cambodia and Vietnam, Trexler, PI).

From information provided to the EET, it appears the FFS, hands-on activities and demonstrations, and participatory workshops have been the most successful ways of transmitting knowledge to small farmers or trainers. This has been successful in most of the projects undertaken to date including: postharvest training at the Postharvest Training Service Center (Barrett, PI), the Savings Led Microfinance Scheme (Miller, PI), the introduction of improved African indigenous vegetables (Weller and Simon, PIs), the introduction of nets to protect plants from insects (Ngouajio, PI), the development of EMINA and other technologies for enhanced safe vegetable production in Cambodia and Vietnam (Trexler, PI) and the project on development of diagnostic tools for rapid detection of *Phytophthora* (Ristaino, PI).

2. *How have research outputs been disseminated at the regional and global level? What tools have been used (i.e. hosted events, publications, web sites) and how effective have they been? Give examples.*

The Horticultural Innovation Lab has made serious endeavors to disseminate the outputs from their program as widely as possible. The Horticultural Innovation Lab web site lists a wide range of information sources and types that are freely available. These include:

Brochures
Newsletters
Fact sheets by theme (Fact sheets on extension are being translated in Arabic and Bangla)
Fact sheets by region
Videos about projects
Project overviews
Partners, researchers and organizations
Overview of RICs
Trellis Fund projects
Technologies overview
Project list
Project narratives by region/country
Annual reports
Conference posters

Fig. 6. Hort CRSP News.

They have developed a widespread network of contacts that receive regular copies of the quarterly Newsletter. This provides information about progress of the Horticultural Innovation Lab, new developments, upcoming calls for proposals, new meetings and importantly success stories emerging from the projects, plus any other news relevant to the Horticultural Innovation Lab or horticultural research in general that might be of value to PIs and the broader Horticultural Innovation Lab audience.

Fig. 7. Examples of outputs from selected projects: (left) Tomato Grafting Guide (Miller, PI); (center) web site for Pest Exclusion Nets (Ngouajio, PI); (right) Manual for *Phytophthora* diagnostic tools.

A combination of tools has been used for disseminating information arising from the projects. At a regional level these include: farmer field days, seed fairs, demonstration plots on farms, lectures and hands-on learning generally provided by in-country personnel as well as visiting US PIs, videos, a comprehensive Horticultural Innovation Lab web site, CDs, TV and radio. Videos for some projects are available from the Horticultural Innovation Lab web site; they are quite simple stories outlining the fundamental reasons for undertaking the investigations and indicating the expected outputs that will benefit smallholder farmers. In addition, a manual has been produced in Spanish on procedures to diagnose *Phytophthora* soils in Central America, and there is a manual/guide on tomato grafting for smallholder farmers in Kenya and neighboring countries (Fig. 7). One project has created its own web site using the title 'BioAgroNet' where information is available to a wide audience (Low Cost Pest Exclusion and Microclimate Modification Technologies for Small Scale Farmers in Africa; Ngouajio, PI); this project has been featured in articles written about the technology in local horticultural trade magazines including the East African Fresh Produce Journal Horticultural News and The Daily Nation, a major metropolitan daily in Nairobi (Fig. 8).


DAILY NATION

ONLINE REAL ESTATE FAIR

East Africa's largest & most popular website presents the online 'real estate' fair.

Crops spend the night under mosquito nets

Fig. 8. News item in the Kenyan newspaper The Daily Post, May 2012, on the pest exclusion nets project.

Tools used for dissemination are broad and attempt to be appropriate for the intended audience. They include presentations and hands-on activities at Farmers Field Schools, trials involving demonstrations of new technologies on smallholder farms, demonstrations of new technologies including improved seed varieties and fruit selections at seed fairs and field days at local institutions, hands-on demonstrations of equipment use, videos, articles in newsletters, discussions with USAID Missions and local NGOs. In addition, a number of scientific papers in local and international journals are now beginning to appear; this output will increase as the projects are completed and final data sets have been analyzed. Some examples include:

- The project New Technology for Postharvest Drying and Storage of Horticultural Seeds (Bradford, PI) used posters, PowerPoint presentations to seed industry personnel, publications and showcased the project and the drying beads in front of Her Royal Highness Princess Sirindhorn at Kasetsart University on the occasion of the launching of the Regional Center of Innovation in Bangkok; the occasion received widespread TV and newspaper coverage, enhancing the reputation of both the Horticultural Innovation Lab and the host university. Kent made another presentation at the launching of the Regional Center of Innovation in Kenya in front of farmers and other private sector people with very favorable feedback.

- Another successful PP involved postharvest training of 36 trainers from six countries in Sub-Saharan Africa (Extension of Appropriate Postharvest Technology in Sub-Saharan Africa: A Postharvest Training and Service Center; Barrett, PI). After an 18-month training program, each individual was provided with a CD containing all the training material (readings, data sets for analysis, product postharvest information) that they retained and used as a basis for subsequent training activities in their own countries. As of October 31, 2012, the original 36 trainees estimated that they had trained more than 8,500 other people in postharvest technologies in their own countries using the CDs, demonstrations, workshops and field days. In addition, Dr. Lisa Kitinoja created a very successful Linked In web site to which some of the trainees belong and on which she has established an online postharvest training course (fee payable) and information portal, both of which are proving very popular.
- The pilot project Safe Vegetable Production in Cambodia and Vietnam: Developing the HARE Network to Enhance Farmer Income, Health and the Local Environment (Trexler, PI) used a combination of techniques for information dissemination. Working very closely with the in-country PI, Dr. Vong, and his staff and students at the Hanoi University of Agriculture, they embarked on an information transfer program that included: hands-on learning to develop EMINA products (bio fertilizers, and bio pesticides); hands–on learning and demonstrations of modifying melon plant architecture to eliminate the costly use of wooden trellis structures; hands-on learning to produce seedlings for transplanting as a more effective alternative to broadcasting seeds; establishment of "Photo Voice" whereby

Fig. 9. EET meeting with farmers using EMINA and other new technologies in Vietnam

farmers photograph a sequence of management systems and options and then learn to develop the correct sequence in which these must be used on the farm to optimize yield and quality of their products. At least two farmers have established independent businesses, one supplying EMINA stock solutions and the other producing seedlings for transplants, for sale to other farmers in their own and other villages. In addition, Dr. Vong has established an excellent relationship with a local TV company; whenever Dr. Vong is organizing a farmer field day, or has distinguished visitors, the TV company accompanies the team, films and then shows a short documentary on local TV – a great way to highlight the project, the local partners, the Horticultural Innovation Lab and USAID.

At a global level, IAB members and the Director attend meetings at which they promote the existence of the Horticultural Innovation Lab and outline its major goals and objectives as well as extol the success stories achieved to date. For example, Dr. George Wilson was a keynote speaker at an International Society for Horticulture Science meeting on postharvest science and spoke on the role and activities of the Horticultural Innovation Lab. It is expected that PIs will also indicate their involvement with, and advocate for the Horticulture Innovation Lab whenever possible, but the effectiveness of this aspect was not possible to check.

Although the Horticultural Innovation Lab is relatively new, many PIs have made poster presentations at international and national meetings as well as the annual meetings of the Horticultural Innovation Lab. Some PIs have commenced publication of results obtained in international, peer-reviewed journals, and a number of papers have been submitted pending successful review and acceptance. The number of published papers is expected to increase over the next two years as projects are completed within the next 12 months.

The appointment of a full-time person responsible for communications should enhance the value of the Horticultural Innovation Lab to promote its activities and successes more widely. It was disappointing not to see a reference to the Horticulture Innovation Lab in a recent (2012) CRSP publication "Harnessing science to 'Feed the Future', the CRSP contribution to achieving food security and improving nutritional status." Major basic and adaptive research and development activities involving African Indigenous Vegetables are currently underway (Weller and Simon, PIs). It is very important that the other nine CRSPS are fully aware of the project outputs from the Horticultural Innovation Lab and more effort is required to produce success stories of interest to a wider audience outside the Horticultural Innovation Lab.

It has been found that the best method of communicating research outputs to farmers varies according to country. For example, radio and video are preferred in Tanzania, Ghana and Ethiopia, while use of mobile phones is rapidly gaining in popularity throughout the region. Use of other methods, such as cheap, streaming laptop computers has not been evaluated in the Horticulture Innovation Lab project to date. However international agencies, such as the Commonwealth of Learning (www.col.org), which is based in Vancouver and works exclusively with past and present British Commonwealth countries, claim to have had success in communicating important and relevant information to smallholder farmers using modern information technologies that are available through personal communication devices such as smart phones. This organization has been at the forefront of developing cheap (<$50), reliable, solar-powered laptops that can be used by smallholder farmers. Although the ME is well aware of the potential of these technologies, there seems to be no concerted effort to develop and adopt such technologies for making project information available to farmers and trainers. It is suggested that this aspect should be emphasized more prominently in the next five-year phase.

The successful launch of the Regional Center of Innovation in Bangkok, Thailand, with the widespread national publicity generated about the Horticultural Innovation Lab and the drying beads project, highlighted the real positive advantage in having a celebrity (in this case Her Royal Highness Princess Sirindhorn) associated with any major event being organized at the Regional Center of Innovation or activity such as a field day to introduce new technological advances. Although it is recognized that there are difficulties involved in getting important national figures to appear at local functions, it is strongly suggested that the Horticultural Innovation Lab senior members, together with the Directors of Regional Centers of Innovation, make serious attempts to attract a minister of the government, an ambassador, or some visiting dignitary who is committed to solving hunger, poverty, nutrition and health problems in developing countries.

The Regional Centers of Innovation have the potential to generate information of both local and regional significance. The Directors should be encouraged to develop close associations with individuals in local news media outlets (including newspapers, radio and TV), utilize the facility to showcase new technologies, host seminars and workshops on relevant topics taking advantage of the presence of visiting experts or dignitaries, and to ensure that a series of interesting items about the Regional Centers of Innovation and Horticultural Innovation Lab emerges regularly.

3. *Does the Innovation Lab have a plan for technology dissemination? What is it?*

The Horticultural Innovation Lab has a comprehensive plan for technology dissemination. The ME provides a great deal of detailed information on a web site separate from the Horticultural Innovation Lab site. The information management program ensures programmatic integration by capturing and sharing lessons learned, analyzing activities, responding to needs and identifying priorities within the projects and centers. Information management activities are integral to the Horticultural Innovation Lab model and provide a platform to continue building future activities based on past successes and challenges.

Information management is an essential component of all programs. It is closely allied with all funded projects and the Regional Centers of Innovation. Its objectives include:

- Providing a clear summary of information management activities and key outputs;
- Improving access to information on useful technologies and where they can best be applied;
- Improving access to information on enhanced and novel dissemination methods.

Its outputs include:
- Clear summaries of information management activities and lists of key outputs;
- Documents listing and activities promoting information useful technologies (with key indicators of where best applied) available;
- Documents listing and activities promoting information on improved dissemination methods that become available.

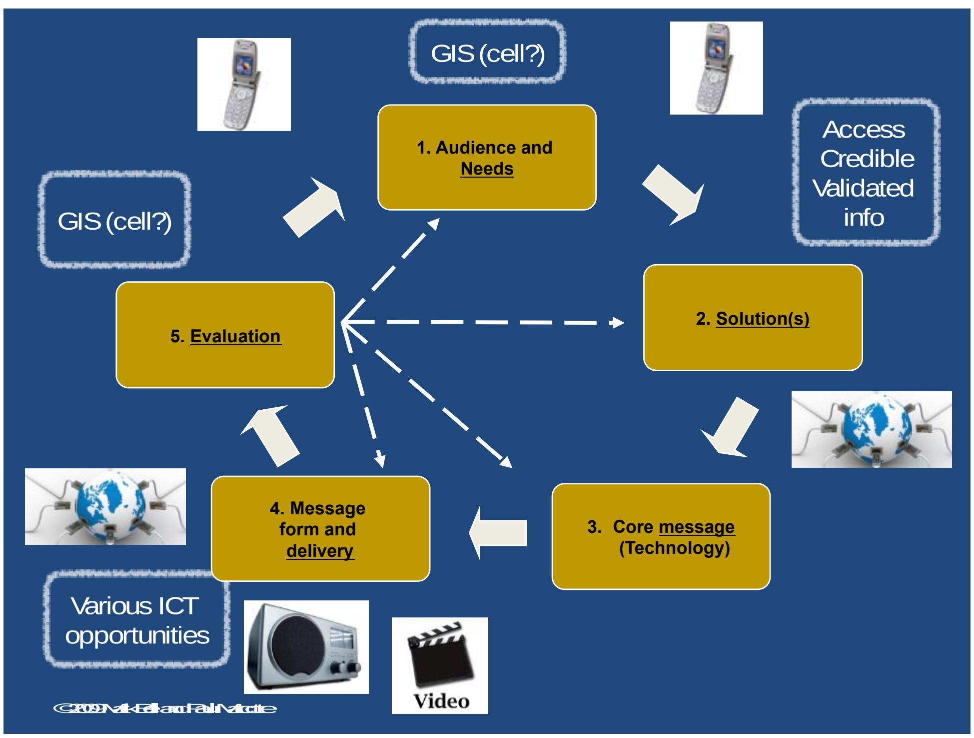


Fig. 10. An outline of the model used by the Horticultural Innovation Lab in the development and delivery of their communication and dissemination outputs.

These outputs are disseminated at workshops organized with PIs involved in specific projects, at the annual meetings that many of the PIs attend, through the web site, through the Regional Centers of Innovation, and through meetings and communication with partners.

In addition, the Horticultural Innovation Lab has recently created a very important position and employed a full-time information and communications person who will increase the output of prepared success stories and new developments for inclusion in the quarterly newsletter. This person is responsible for public relations, information management, web site management, preparing newsletters, taking care of social media, preparing fact sheets and working with external news media. She also prepares information packages for USAID, partners and others. She is planning to produce a list of publications, presentations and reports from Horticultural Innovation Lab personnel, and she is preparing a list of conference proceedings and presentations. She is able to plug into the University of California, Davis and USAID information Internet systems. She has plans to include the H Horticultural Innovation Lab in social media such as Facebook, Twitter, Flickr and include a photo showcase. All of the above is done in close collaboration with Mark Bell, the ME member in charge of the Information and Communication Unit and other senior members of the ME. This is an important position that will facilitate dissemination of critical information to the science community, to USAID, to the subscribers to the Horticulture Newsletter, to PIs and to the general public.

4. *Evaluate the dissemination of research results and the effectiveness of their utilization as a measure of the appropriateness of the research.*

With more than 18,000 individuals (>50% women) having been exposed to, or influenced by, Horticultural Innovation Lab training sessions, workshops and farmer field days, either directly by attendance or indirectly through subsequent training by the trainers, the dissemination of research results has been impressive in the short time since the inception of the Horticultural Innovation Lab. The projects have reached 4,935 rural households, and more than 5,000 people have adopted about 40 new technologies and/or management practices. More than 75% of farmers who have adopted new practices and 61% of farmers trained have been women. Horticulture Innovation Lab PIs and their ~80 partners interacted with more than 40 women's groups, 100 private enterprises and 40 community based organizations. More than 10,000 ha are now under improved management regimes following Horticultural Innovation Lab interventions.

The Horticultural Innovation Lab has supported research along the horticultural value chain. While many projects are still in progress and final results will not be available until 2014, projects to date have:

- Found tomato and chili varieties from Taiwan that grow well in Central America and certain species of leafy green vegetables that perform well in Kenya, Tanzania and Zambia. New varieties of the above two vegetables are resistant to disease and are accepted by local growers and families;

- Developed and improved BIOAGRONETs for pest exclusion together with modified production management protocols;
- Developed a reflective system that concentrates the sun for use with typical solar dryers and reduces drying time while being easily built and transported under developing country conditions;
- Developed and tested a weaning food made with orange-fleshed sweet potato puree;
- Developed GAPs for tomato production in Nigeria;
- Tested information management strategies. In Central America, it was found that food safety information was not being transferred through typical extension channels. In Africa, it was learned that it might take more than a typical farmer field school to extend horticultural technologies and good practices.

At least three new technologies have been evaluated enough and are ready for scale up. These include:

- The CoolBot temperature control system for low cost cool storage;
- Seed drying beads;
- Pest exclusion nets.

Each of these technologies continues to be refined and improved, but each has demonstrated great potential for commercial adoption and uptake. User manuals are being prepared for these three technologies.

Other technologies that have great promise for scale up but await final test results include:

- Solar drying of vegetables;
- Solar soil sterilization;
- OFSP drying for flour;
- Vegetable grafting;
- *Phytophthora* spp. diagnostics;
- Solar powered irrigation;
- Effective microorganisms (EM) as bio fertilizers, bio pesticides and for speeding compost preparations;
- Zero- cost cooling chambers.

Fig. 11. New technologies demonstrated with potential for application and scale up to small farmers. Solar dryer, Thika, Nairobi (left); preparation of EMINA, Hanoi, Vietnam (center); zero cost cooling chamber, Arusha, Tanzania (right).

In general, the dissemination of results is done effectively and efficiently, but in some cases in-country PIs indicated to us that they were not trained in how to communicate directly with smallholder farmers. They understood the Horticulture Innovation Lab strategic requirements and the steps that should be taken, but they expressed uncertainty about how best to transfer information at the final stage of the process to the farmer. This indicates that there may be a gap between the theory and application of effective communication technologies. It is suggested that the Information Management and Communications team consider organizing some workshops in different regions in order to instruct and demonstrate the most effective methods for transferring new knowledge and technologies to smallholder farmers. This should involve role playing and participant involvement rather than lectures. It should also demonstrate ways and means to stimulate private companies to become involved in providing, marketing and hopefully adapting new ideas and technologies to farmers in their respective regions.

A limited amount of feedback from smallholder farmers, who had participated in projects, was available to the EET. Both technical and personal benefits followed the development of the project: Increasing Capacity of Smallholder Farmers to Produce and Market Vegetable Crops in Uganda (Scow, PI). Responses from some of the women who benefited from their involvement in this project are listed as follows:

- Developing community seed systems: Most FFS groups developed local supply systems in response to poor availability and quality;
- Adoption of fertility amendments for vegetables:_About 75% of participants that grew crops began using some kind of fertility amendment they learned in the FFS;
- Women's economic empowerment: About 60% of participants that grew the crops are now selling a portion; about 70% of those selling are women; a number of participants reported improved self-esteem and personal dignity;

- Improved Diets and Household Health: About 1/3 of participants reported improved diet/health as one of the most important changes caused by participating;
- Improved household income and consumption: Participants reported a major change and better access to income for both daily needs (such as soap, sugar, medication) (~40%) and school fees (~12%);
- Friendship: The most commonly reported positive change.

The EET is convinced that many of these personal reflections of participants in this project apply to those who have been involved in other projects as well. Personal anecdotes from the PIs of the "Seeds of Hope" project in Central America, the Postharvest Training in Rwanda and Arusha, Tanzania, the Safe Vegetable production project in Vietnam and the African Indigenous Vegetable project all received similar comments from participants. These reflections provide a positive reinforcement of the value of the technical information generated and transferred to smallholder farmers; in addition, they demonstrate that other very positive sociological and economic benefits flow from participation in such projects.

***5**. Has the Innovation Lab partnered with the right collaborators to implement and disseminate the outputs of the research program? Who else should they partner with?*

In general, the collaborators chosen by the US PIs have been very effective in their involvement in the experimental programs and have been fully involved in organizing and undertaking most of the farmer field days and other training programs. While most of the partners have been at local universities, research institutions (such as KARI in Kenya) or private companies (such as Rhino Research Ltd in Bangkok), there should be an opportunity to link with local university personnel. For example, an individual at Jomo Kenyatta University was not included in the original team despite the fact that she was working on AIVs. Whilst participating at the opening of the Regional Center of Innovation she was able to make personal contact with Weller and Simon and they were very willing to include her in the team for the remainder of the project. The EET was told that this involvement brought prestige and some recognition to both the individual and the institution. It was clear to the EET that those in-country PIs who had had postgraduate experience abroad seemed to have the most confidence and drive to mount expansive, broad based and effective information transfer systems to deliver the outputs to their audiences. In addition they seemed to have generated contacts with others in the supply chain, such as marketing personnel, and the media.

This point underlines the importance of international experience and exposure of host country PIs. It also indicates that long-term advantages will follow from educational programs that send high quality students to undertake PhD training at the US land-grant universities. It suggests that as funds permit, there should be an increase of scholarships/fellowships to enable a greater number of host country PhD scholars to be educated in the US.

It is also important that strong links be made with host country universities to assist with the training of MS students. Many universities in Africa are re-evaluating their curricula for plant science and horticulture degrees to ensure that graduates have the appropriate training for their eventual employment within country. There is a real opportunity for the US land-grant university faculty to join with other agencies involved in education and training to assist with these objectives perhaps through linking Horticulture Innovation Lab PIs with others involved in projects such as InnovATE (Innovations in Agricultural Training and Education) and AWARD (African Women in Agricultural Research and Development).

There are opportunities for involving other collaborators to undertake collaborative research, as well as to implement and disseminate research outputs; these are indicated under question #6, below. Briefly, collaborations should be made as follows:

- Within the Horticultural Innovation Lab by ensuring that relevant results are made available quickly so they can be evaluated in other regions;
- With other Innovations Labs for appropriate collaborative research;
- With other Innovation Labs for dissemination of relevant information through their respective networks;
- With USAID Missions and their implementation agencies such as FINTRAC and DAI;
- With other international development and funding agencies including the World Bank, FAO, CGIAR institutes and NGOs such as OXFAM and CARE just to name a few.

While significant steps have been made to develop and demonstrate new technologies and practices that are of value to smallholder farmers, there must be further attention given to the idea of scale up. It is suggested that at the project proposal stage all applicants for projects be requested to indicate how results and technologies that might flow from their projects could best be scaled up for wider adoption in a host country. All prospective PIs should give some consideration to this point. To enable PIs to grasp the significance of this aspect of the Feed the Future program, it might be necessary for the Horticultural Innovation Lab /USAID to organize some interactive workshops involving some Mission personnel as well as implementing partners such as FINTRAC or DAI, to provide guidance and elucidation to all PIs.

6. *Are there any unexplored areas of collaboration between projects that are feasible and have potential? Give examples.*

Within the Horticultural Innovation Lab. In the next five-year phase, the Horticultural Innovation Lab should explore mechanisms for more rapid transmission of ideas and preliminary results among PIs within the H Horticultural Innovation Lab. For example, in the project on Safe Vegetable Production in Vietnam (Trexler, PI), the EET was very impressed with the performance of the biological control systems using EMINA solutions that appeared to provide a sustainable pest control system and thus major reduction or elimination of chemical residues from fresh vegetables. Yet there was no evidence that this exciting development was being used elsewhere within the Horticultural Innovation Lab, not even in the partner project in Cambodia let alone in any of the African projects on indigenous vegetables. It is understood that this experiment has not been completed yet, but promotion of preliminary results could and should have been shared with other PIs.

Between Innovation Labs. The main issues that are being tackled by the Horticultural Innovation Lab relate to sustainable production and postharvest systems for nutritious fruit and vegetables in developing Feed the Future countries as designated by USAID.

It is clear that the Horticultural Innovation Lab has overlapping interests with some other Innovation Labs, namely Integrated Pest Management (IPM), Global Nutrition, Sustainable Agricultural and Natural Resource Management (SANREM) and BASIS Assets and Market Access (AMA). Considering the health ramifications of nutrition on health of children and women particularly, there is every incentive for collaboration and communication among several of the Horticultural Innovation Lab projects, such as Postharvest Technologies, Safe Vegetable Production and African indigenous vegetables with Global Nutrition projects. Similarly, the Horticultural Innovation Lab emphasis on sustainable production of safe healthy fruit and vegetables by minimizing application of synthetic pesticides and encouraging biological methods of control has much overlap with certain objectives of the IPM CRSP and SANREM. The CP, African Indigenous Vegetables (Weller and Simon, PIs) has an entomologist on the team to look into the pests and disease problems. Similarly, the educating smallholder vegetable farmers in grafting and microclimate management techniques in Kenya, Tanzania and Uganda (Kleinhenz, PI) project has Sally Miller, a plant pathologist on the team and she has presented the results of grafting in vegetables to overcome soil borne diseases at the IPM Innovation Lab meetings. Such examples clearly indicate that the ME is well aware of the value of synergies between different Innovation Labs. Recently, the ME has also entered into an arrangement for a joint award for a project with the SANREM Innovation Lab. The ME is keen on promoting such inter-Innovation Lab collaboration wherever possible and applicable to complement and enhance the value and outcomes, and to avoid duplication of efforts.

With the USAID Missions. The Missions are the implementers of agricultural innovations and technologies and are responsible for scaling up of promising outputs in farming systems in target countries. They have very large budgets at their disposal especially in comparison to the Horticultural Innovation Lab In general, the relationships between the PIs and the Missions are adequate; the ME has developed a protocol for ensuring PIs communicate with Missions prior to visiting host countries and set up meetings well in advance of their visits. However, the Horticultural Innovation Lab has had little success in direct integration with Mission value chain projects in Horticulture. In the next five-year phase, such relationships need to be pursued more aggressively. Many opportunities exist since many Feed the Future Missions have horticultural value chains as a top priority (e.g., Kenya, Tanzania, Cambodia, Nepal, Bangladesh, Guatemala, Honduras, etc.). The ME was successful in working with the Mission in Honduras and has an Associate Award for Horticulture Value Chain Assessment. (See Recommendation 3.)

With other international agencies. There are many other international agencies and NGOs operating in the development arena. Most of these have agendas similar to that of the USAID Feed then Future program. Some important agencies including the United Nations Food and Agriculture Organization (FAO), The World Bank, the Asian Development Bank, the United Nations Development Program (UNDP), relevant CGIAR institutes, OXFAM and CARE, are all actively involved in the same countries as the Horticultural Innovation Lab. The Director of Horticultural Innovation Lab has met with representatives of a number of these agencies and briefed them on the activities of the Horticultural Innovation Lab. The ME is planning to continue to seek their collaboration with the Horticultural Innovation Lab. The Horticultural Innovation Lab has now established the Regional Centers of Innovation in the three regions, and they are expected to serve as conduits to engage with several of these international and regional donor agencies and NGOs. Again, there are a number of agencies involved in capacity building, of both personnel and institutions in the Feed the Future countries. Education, learning and training are key platforms in the Horticultural Innovation Lab projects, so awareness and possible collaboration with other major regional programs may prove beneficial in the future.

For the Horticultural Innovation Lab to increase and develop relationships/associations with other Innovation Labs and national and international agencies, the Director of the Horticultural Innovation Lab is taking an active role through participation in national, regional and international conferences that are involved with food production, food security, the role of women, health and nutrition of women and children and even in events that target education and training of those in the food chain. If the Director became a full-time position then this advocacy and promotion role could be further expanded.

Recommendation 8. We recommend that the ME Information Management and Communications team and in particular the new communications coordinator work assiduously to develop close links with news editors in all branches of the media in order to create better opportunities for wider distribution of interesting, good news and successful stories flowing from Horticultural Innovation Lab activities. Such stories are fine to have at a local level but they need to find places in national and international outlets.

Recommendation 9. We recommend that the ME Information Management and Communications team further develop social media systems for communicating messages of hope and success related to the role of horticulture in reducing poverty, increasing food security, improving health and nutrition of women and children, increasing household incomes, producing safer food and vegetables for household and market consumption.

Recommendation 10. We recommend that the ME Information Management and Communications team establish links with the Commonwealth of Learning to determine the processes and protocols that they are using to help smallholder farmers gain knowledge of technologies, management and markets using modern ICT technologies and determine if there is any opportunity for collaborating in selected past and present British Commonwealth countries.

VIII Gender Inclusion

The Horticultural Innovation Lab program has been very successful, in general, in ensuring that strong gender inclusion/equity emphasis is maintained throughout their portfolio of activities. By way of example, the IAB has four female members out of a total membership of 12 (33%). The ME has a staff of 11 (many part time) comprising nine women and two men.

1. *Does the Innovation Lab have a formal plan for gender inclusion in all of its activities?*

Being one of the most recently established Innovation Labs, the Horticultural Innovation Lab has a strong strategic and tactical emphasis on gender inclusion and equity in its programs. The Innovation Lab does have a plan for gender inclusion. Associate Director Amanda Crump leads the gender inclusion aspect of all projects. It is recognized that women are the traditional cultivators and marketers of horticultural crops with up to 80% percent of the labor force in many countries where vegetables, fruits, and cut flowers are considered to be "women's crops". Although women represent a large reservoir of production and marketing knowledge of these crops, they are usually compensated with lower wages and less permanent positions than men. Lacking knowledge of how finance works and where to get it, as well as collateral to insure it, women have unequal access to technology.

When provided with appropriate and equitable training, women growers are well poised to increase productivity and expand horticultural markets. All projects must consider gender and enabling environment issues. Project proposals specifically addressing gender inequality are expected to evaluate gender-based constraints, provide leadership and technical training, and provide outreach or policy assistance to develop solutions. Some training activities are expected to target women, including training for female extension specialists. The Horticultural Innovation Lab Gender Equity strategy ensures that women are reached in meaningful and empowering ways.

It is the role of the gender specialist in the ME to ensure that all programs are fully accessible to women. That means more than just simply training more women than men, but actually working with all projects to ensure that women who are trained are able to access technologies and information. For example, simply getting women to attend a training session does not ensure information is transferred to them in a meaningful way that works for them (for example, they may have different literacy needs). The ME specialist works closely with each project during the funding stage to ensure that their gender plans make sense. For example, in the seed-drying project, the project team initially proposed to try to understand how to create small businesses for drying seeds. During the proposal revision process, the ME gender specialist worked with the PI to adjust that goal to create small businesses for women. To do this, the PI had to understand how laws around creating small businesses might not favor female participation in creating these businesses. But the PI was set up to do that with appropriate resources. Some of the projects have very strong gender specialists as collaborators and those usually require little adjusting, but the ME gender specialist makes sure that everything that is done with people gives access to both men and women alike by tackling barriers that keep either gender from participating in and benefiting from Horticultural Innovation Lab activities. The ME specialist is very much in tune with the current USAID gender team and their gender strategies and also relies heavily on gender strategies developed by the World Bank and the UN. Recently, the ME gender specialist was invited to attend a gender global learning exchange where she shared ideas with and learned from other gender specialists.

2. *How has gender been taken into consideration in research design, training and outreach strategies? What have been the results? What areas could be improved and how?*

   Every Horticultural Innovation Lab project must include a plan for gender equity in the original proposal. Guidance is provided during project planning to ensure that the needs of women and men are appropriately addressed within each project. Gender equity plans are developed with project leaders while ensuring that Horticultural Innovation Lab projects result in increased learning and empowerment for women. Gender equity training is also provided. At the end of the first three years, more than 18,000 farmers had been reached with the Horticultural Innovation Lab training and research projects with more than 50% of these farmers being women. More than 4,900 households have been affected by training and more than 100 new technologies have been adopted by trainees (60% women). In some projects, women dominate. For example, in the Savings Led Microfinance (SLM) project in Cambodia more than 80% of the participants are women, and in the Safe Vegetable Production project in Vietnam the most successful uptake and development of new production technologies appeared to be done by women. The impact of the project was seen in the development of two small independent businesses arising from the new technologies being used in the project, including production of stock solutions of the bio pesticide, bio fertilizer and bio-composting media as well as the production of seedlings for transplanting, both for sale to other farmers in their local and neighboring villages and communes.

Thirty-six postharvest specialists (19 women, 17 men) from eight neighboring countries undertook advanced hands-on training, taking 10 courses over 18 months at the Postharvest Training Services Center based at the AVRDC campus, Arusha, Tanzania. Since the end of the project in 2011, these trainees have indicated that they have trained a further 8,738 people involved in postharvest businesses in their home countries including smallholder farmers. In addition, these latter trainees have trained 3,600 additional people thus adding a further multiplier effect resulting in a total of 12,338 benefitting from this postharvest training project.

Reports from the PIs indicate that women are very keen learners and adopters of new technologies. They are keen to learn. In doing so, they gain confidence in their abilities to produce fresh and processed horticultural food products. In addition, they gain personal pride, confidence and dignity in accomplishing new activities.

Women trained. In three-and-one-half years, the Horticultural Innovation Lab has trained more than 18,000 people of whom at least 51% were women (Table 3; next page). Data gathered was not disaggregated to provide details on the categories of people/women trained. For example, it is not possible to determine the proportion of farmers, extension officers, university staff, or individuals from the private sector who were trained or what numbers of women were in each of these categories. However, nearly 140 women's organizations or associations were assisted because of project intervention. Almost every project has a train the trainer component, but the numbers requested by USAID are simply for number of people receiving short-term (which is non-degree) training. All numbers (including the student numbers) are current as of October 1,

2012. Reporting on indicators is done annually at the end of fiscal year in October.

Table 3. Number of people trained over three years (2010, 2011 and 2012) of the Horticultural Innovation Lab program indicating number of women's groups, females and males trained.

Category	**2010**	**2011**	**2012**	**Total**
Number of women's organizations/associations assisted as a result of USG interventions.	47	49	42	138
Number of **Females** who have received USG supported short-term agricultural sector productivity training	1,258	1,300	3,158	5,716
Number of **Males** who have received USG supported short-term agricultural sector productivity training	1,035	1,462	1,968	4,465
Number of **Females** who have received USG supported long-term agricultural sector productivity training	4	15	23	42
Number of **Males** who have received USG supported long-term agricultural sector productivity training	4	12	12	28
Disaggregation not available			8,132	8,132
Total people trained	**1,266**	**2,789**	**13,293**	**18,383**

University (long term) training. Not only is training of women farmers a priority, higher education opportunities for women is an important element of capacity building and sustainability for future academics (teachers and researchers), extension officers and skilled graduate personnel for the private sector. At least 108 students were being trained at universities in the US (42 students or 39% of the total) while 66 students (61% of the total) were being educated and trained in host countries, all with partial or sometimes full funding. Students have been involved in diverse projects undertaken by the Horticulture Innovation Lab. A list of participating universities and project PIs is provided in Appendix 8. There were slightly more females being trained (58%) than males (42%) for bachelor, masters and PhD degrees (see Table 2, pg. 55).

Social science input into projects. The ME does a very good job in ensuring that gender issues are satisfied in all successful projects. However, in the future it is suggested that when proposals are solicited that it is stated clearly in the conditions that each project team should include, where necessary, a person with social science expertise preferably one from each of the US and in-country project teams.

The ME is to be congratulated on developing a strong strategic direction and implementation for gender inclusion in their overall program. The current Associate Director is a strong and able leader for this Gender Inclusion part of the Horticulture Innovation Lab program.

There is a need to identify the specific economic and social benefits that flow from Horticulture Innovation Lab projects. This could be achieved by using social scientists involved into relevant projects or collaboration with social scientists and/or agro-economists from other appropriate Innovation Labs. Such involvement would enable the benefits to households and communities emerging from adoption and application of specific horticultural technologies to be determined

Recommendation 11. The EET recommends that the current protocols and practices undertaken by the ME to ensure gender equity and inclusion on all Horticultural Innovation Lab projects be commended and that efforts be maintained to ensure that a person with expertise and experience in social sciences (such as sociology, anthropology) be included in all future project teams where practicable to ascertain benefits emerging to households and communities from adoption of innovative horticultural technologies..

IX. Monitoring and Evaluation

1. *What types of monitoring and evaluation have been undertaken by the ME? Are social scientists used to conduct broad impact assessments?*

The ME has instituted a Monitoring and Evaluation (M&E) team, composed of an internal advisor (Amanda Crump, Horticulture Innovation Lab Associate Director) and Dr. Paul Marcotte (University of California, Davis, International Programs Office); Erin McGuire, a project intern, has also been helping with the evaluations. The team has training in both natural and social sciences and the members are able to conduct both qualitative and quantitative assessments. The M&E team has been active from the start of the Horticulture Innovation Lab Program and serves as a mechanism to evaluate progress of the projects, provide comments and recommendations to the ME, and to provide guidance to Horticulture Innovation Lab team members on data collection methods for baseline surveys, project monitoring, and reporting.

The M&E team has a work plan that includes the monitoring and evaluation of four main components:

- Assessing project progress towards objectives.

- Assessing outputs – project activities, products, trainees, and other items.
- Assessing outcomes – the direct changes seen in people or production systems as a result of Horticulture Innovation Lab projects.
- Assessing impact – the changes that are beyond the outcomes or the things that have changed in the community or ecosystem as a result of Horticulture Innovation Lab projects.

Specific methodology includes the following:

Assessing Project Progress

At the proposal stage, projects funded by Horticulture Innovation Lab develop a log frame monitoring and evaluation plan based on their objectives. The projects address their objectives through defined activities that have specific outcomes and measures of success. The M&E team requests that project teams critically think about how they will measure and document their success and how they envision the impact of their project.

Every six months, project leaders are asked to advise the Horticulture Innovation Lab M&E team about the progress they have made towards their objectives. In addition to reporting on their objectives, the project leaders are asked to complete a standardized project report. Annually, this report is assessed to ensure that projects are making timely progress.

At the midpoint of each project, project leaders are contacted by Paul Marcotte to assess their satisfaction with their project and with the Horticulture Innovation Lab ME. Because Paul is outside the ME, he has been able to suggest changes to the management system through his reports of this interaction. At the end of a project, several steps occur including a detailed review by the entire M&E team of the project to determine if the project achieved its objectives, which project aspects were successful and could possibly be scaled up, and how the project contributed to the overall mission and goals of the Horticulture Innovation Lab.

Assessing Outputs

Outputs are assessed utilizing Feed the Future agricultural indicators selected by the Bureau for Food Security at USAID. In addition, the Horticulture Innovation Lab has developed a set of indicators for capacity building, with specific questions pertaining to agricultural production, postharvest, marketplace, or 'other' issues. These indicators are assessed every six months and reported to USAID annually in October. At the beginning of projects, the project leaders propose output (indicator) targets that are appropriate for their projects. It is this list of targets that projects are judged against. Project leaders, in consultation with the Horticulture Innovation Lab ME, are allowed to revise their indicators on an annual basis. Assessing outputs in this way is quantitative and gives the Horticulture Innovation Lab ME the ability to measure a number of different indicators quickly. While not indicating impact, these outputs do inform the ME of how projects are progressing and the overall effect the entire Horticulture Innovation Lab portfolio is having and where there may be gaps.

Assessing Outcomes

If a member of the ME visits one of the Horticulture Innovation Lab projects in the field, they are asked to interview project team members. A standardized set of interview questions is provided for this activity. These interviews are recorded, transcribed and then analyzed qualitatively to understand the direct changes that the projects are having for the people involved in the project. Horticulture Innovation Lab team members are also asked to assess the project on the ground. In addition to these on-the-ground assessments, the M&E team measures outcomes from the report narratives that the project leaders write every six months. These project narratives and on-the-ground reports help them understand what is happening to the people and the production systems in the projects. These outcomes also guide the ME as they decide which projects to target for potential scale up and where to invest in upcoming years.

Assessing Impact

Measuring impact is one of the more difficult propositions for the M&E team to assess. The approach proposed has been to visit the project sites at least one year after the end of the project. These site visits are used to determine the impact of the project's efforts in capacity building, developing collaborations, and technology implementation. These visits also allow the M&E team to understand how people beyond the reach of the project have been impacted and how the community or ecosystem beyond the direct reach of the project has changed.

At the beginning of the later stage Horticulture Innovation Lab projects (i.e., after the IIPs), the project leaders were asked to implement a baseline survey. It is partially against these baseline surveys that the M&E team will measure the Horticulture Innovation Lab's long-term impact and success.

2. *Are the indicators used effective at capturing and communicating the outcomes and impacts of research activities? Are there appropriate indicators for each stage in the "research continuum"? Have indicators capturing impacts and outcomes on higher levels been developed?*

The ME, through the M&E team, has established a broad set of benchmark indicators that have been used to capture and report the outcomes and potential impact of the Horticulture Innovation Lab projects. These indicators cover a wide range of issues and do appear to effectively capture all stages of the research continuum. Furthermore, higher level indicators are evident in their attention to benchmarks for long term goals, such as: sustainability, response to demands and constraints in the value chain, building capacity, improvement of key infrastructure, and development of production, postharvest and market mechanisms to ensure food security and improve the welfare of individuals, their communities and their country.

Examples of some research activity indicators and benchmarks that the M&E team is using are the following:

Increased production of selected horticulture products in host countries

Improved germplasm: Existing horticultural products evaluated by researchers/stakeholders; alternative/improved germplasm developed; indigenous crops and cultivars selected for nutritional and postharvest characteristics.
Benchmarks: Greater knowledge of inheritance of important traits; alternative cultivars developed or recommended with improved traits; release of cultivars and hybrids with higher yield; improved adaptation to biotic and abiotic stresses; enhanced value for producers, marketers and consumers; genetic resources available and distributed.

Improved integrated crop management: Constraints and enabling environment to production assessed; alternative inputs identified; Good Agricultural Practices (GAPs) for production identified and recommended.
Benchmarks: GAPs information and technology developed; extension agents and producers trained in GAPs; increases in production.

Enabling environment: Build institutional capacity; develop financial opportunities for value chain stakeholders; develop appropriate information/technology delivery systems; identify best-adapted crops.
Benchmarks: Stakeholders have greater wealth and improved livelihood; can invest in expansion.

Gender equity: Increase women's access to financing and information about markets; access to production information and improved germplasm; recruit female farmers.
Benchmarks: Increase in women's disposable income; dependability of farmland access or ownership; women informed in food quality and safety; women's knowledge of finance and marketing systems increased; numbers of female scientists and extension agents; new opportunities for women in the horticulture value chain.

Increased value-addition of selected horticulture products in target countries.

Assess constraints to market access: Identify public policies and infrastructure needed for market access; develop enabling credit options for stakeholders; deliver information on finance, marketing and standards.
Benchmarks: Development of policies that improve local horticultural trade and export capacity; improved access of small producers to high value markets.

Investment in host country agri-industry that increases employment and economic development: Assessment of current practices; regional centers established; identify infrastructure changes needed; assess market impediments; work with policymakers toward investing in change; develop interventions to improve postharvest infrastructure; build capacity in tertiary education and research centers in postharvest methods and food standards.
Benchmarks: Reduction in product losses; higher quality produce; training centers fully staffed; 'train the trainer' programs instituted; regional training centers established; food-borne illnesses reduced and nutrition improved; increase in rural income; jobs generated.

Activities across value chains to create employment: Introduce technologies that create local high-skill employment; identify novel products that combine high value with demand; develop domestic seed and plant sources and propagation.
Benchmarks: New technology adoption; poverty reduction; increased rural incomes; new market opportunities; higher skill levels.

3. *Have baselines been established? If not, why?*

The gathering of baseline data was executed more effectively in later stages of the Horticulture Innovation Lab program, than at the beginning. With the one-year IIPs, the ME decided that baseline data collection would be too difficult, in light of the short nature of those projects. Nonetheless, each IIP was asked in the proposal stage to set benchmarks and then report on them throughout the project. With these reports in hand, the M&E team is planning to go back to the IIP locations in the coming year and look at what changes and progress has occurred since the last report. The M&E team also plans to do post-hoc baseline data gathering in some of these locations, using government data and other sources of information; all of this will contribute to their post-project assessments.

All later projects were required to budget for and conduct more extensive baseline surveys. At the completion of each project, the M&E team will re-measure the parameters captured at baseline to determine if a difference has been made with the research. An example of baseline data collection is that of the AIV project's baseline household survey, which included questions on such things as: land use and revenue; what was being grown; input costs; yield; what types of processing (if any) were being employed; household preferences for the consumption of AIVs; buyer preferences for AIVs; what credit opportunities existed; what were the levels of savings.

4. *Are data collected valid and of proper quality for reporting?*

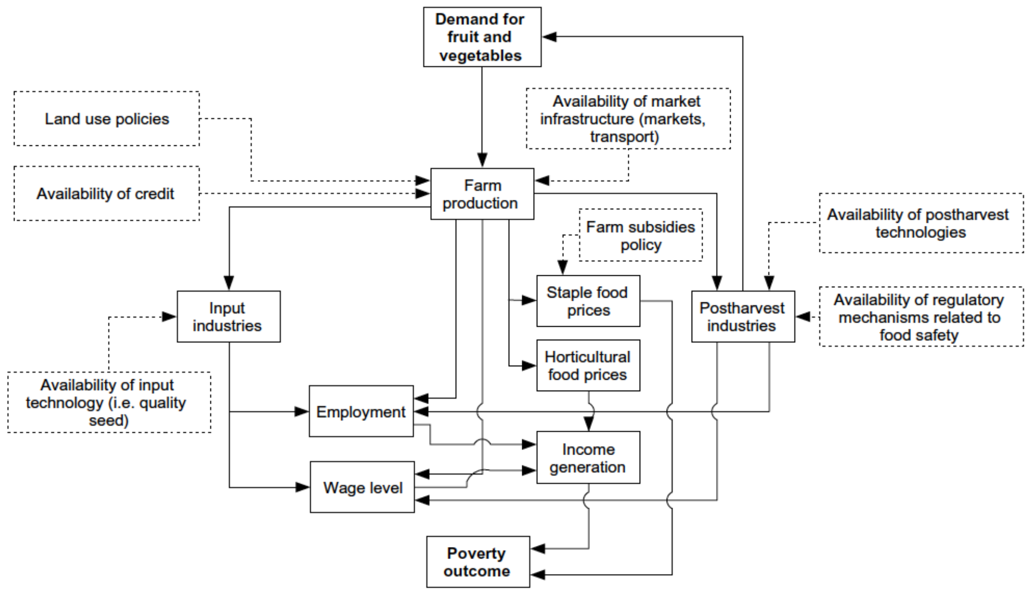
The M&E team has put together very specific guidelines on reporting, having created templates for the PIs to fill out at each stage of their projects. This has given the M&E team an adequate and complete set of information for each project, enabling their evaluation of the project's ongoing progress, or level of success at its completion. Furthermore, the standardized reporting structure has facilitated the ME's requirements to report the progress made on various Feed the Future indicators to USAID.

X. Research Focus of a Second, Final Five-Year Phase if Awarded

1. *Do the results achieved to date justify awarding a second, final five-year phase of the Innovation Lab in the same research area? Why or why not?*

Yes, the EET strongly recommends renewal and continuation of the Horticulture Innovation Lab for another five-year period.
Horticulture is a vitally essential production sector that has the potential to change lives, livelihoods, income, nutrition and health in developing Feed the Future countries. It is a challenging topic as there are many crops with hundreds of genera, species and cultivars available for production, many of which are underutilized and not yet commercialized. In addition, horticultural crops are perishable, fragile and often have very short shelf lives. Therefore, developing an integrated and efficient supply/value chain from farm to market is critically important.

The following is a model that could be applied to demonstrate the complex interactions involved in diversification into production and marketing of high value horticultural crops for poverty alleviation [K. Weinberger and T.A. Lumpkin, "Diversification into Horticulture and Poverty Reduction: a research agenda". *World Development 35(8):* 1464-1480. 2007]



Future Horticulture Innovation Lab projects should endeavor to include all relevant aspects likely to cause bottlenecks or constraints in the supply chain and deliver integrated holistic information packages that can be undertaken on smallholder farms and scaled up for implementation by other players such as the USAID Mission and their contractors.

The Horticulture Innovation Lab has achieved the objectives set out in the original proposal to USAID. They responded with alacrity to the changes that were foisted upon them following strategic and policy changes implemented by USAID 15 months into their current tenure of the program; they demonstrated flexibility, initiative and good sense in adapting rapidly to the new guidelines to Feed the Future directions and have continued to meet deadlines and milestones.

The ME at University of California, Davis has done an excellent task of managing the program. Almost without question, PIs have expressed their praise for the manner in which the ME has managed the projects including calls for proposals, reviewing and deciding on successful applicants, managing the financial and reporting aspects and providing expert advice and assistance to PIs at all phases of their projects. There has been unanimous support from the PIs questioned that University of California, Davis should continue to serve as the ME of this program.

Recommendation 12. The EET recommends that the Horticulture Innovation Lab be renewed and continued for another five-year phase and that the ME remains at University of California, Davis for the second phase with a non-competitive renewal.

2. *If a second five-year phase is funded:*
   a. *What should be the research focus?*

- The second phase should focus on conserving input resources including water, safe vegetable production, reducing food losses and wastage, improving family incomes and improving nutrition of families, with the aim of fulfilling Millennium Development Goals and Feed the Future objectives. Activities should build on results obtained in the first phase, where appropriate, with particular emphasis on introducing adaptive new technologies and demand driven production and postharvest packaging technologies.
- Value chain analysis of horticultural enterprises should continue to be a major focus of the Horticulture Innovation Lab portfolio in providing information on rate limiting steps and constraints (road blocks).
- Appropriate postharvest storage and processing and value added technologies in both vegetable and fruit crops.
- Nutrition and health aspects of horticultural foods for consumption with special reference to Asian and African indigenous vegetables and fruit; this would include the effects of plant stresses on growth and nutritional components; attention to nutrients bioavailability should also be considered.
- Develop production management packages incorporating innovative technologies (including improved cultivars, seed preservation techniques, transplanting, mulching, raised beds, management of plant architecture, micro-irrigation, use of bio pesticides and bio fertilizers, precise fertilizer placement, water storage devices) demonstrated to enhance production of safe vegetables and fruits; these should be developed to a stage for application by extension officers and for scale up.
- Included in any postharvest and/or postharvest management package to be promoted should be a preliminary business development and marketing plan.
- Projects should be designed so results establish key principles that can be transferred to other regions. The ME should encourage PIs to become familiar with new USAID directives and strategy (including New Alliance, Water for Food).

   b. *Should there be an emphasis on fewer high performing activities?*

- The EET believes that the Horticulture Innovation Lab should maintain a balanced portfolio of projects of different sizes and durations.
- The Trellis Fund should be maintained, perhaps extended, depending on finances. It is accepted as being very valuable for introducing young graduates to development horticulture and for host country institutions and NGOs to work with young people who wish to make a difference to smallholders in developing countries.

- Continue to have two to three large projects, each of about $1 million over three years phased in during the five-year period, each with potential renewal for two years.
- Introduce discovery projects, each of $150,000 – $200,000 over two years; opportunities for extension will depend on budget, technical review committee and ME. (The EET was impressed with the success achieved in the first IIPs and EPs where seven out of fifteen projects were extended subsequently into PPs, CPs and continuation projects; this will enable new people to apply with different innovative projects and with new partners in host countries. The EET believes that the Horticulture Innovation Lab needs both expansion and renewal.)
- Introduce an annual prize each year (say $10,000 - $5k for the prize and $5k for development) for the best idea for a new and innovative technology that will enhance and advance the aims of the Horticulture Innovation Lab; this could have a different theme each year. Funds for this purpose could be solicited from prospective and interested donor agencies.

c. *Should the research focus be on one or both of the following, as recommended by the BIFAD Review of Collaborative Research Support Program (CRSP) Model: A Report Commission by BIFAD at the Request of USAID, August 2012: (i.) Strategic research on a global problem, or (ii.) demand driven research to enhance food security at the country and regional level.*

As food security, human health and nutrition and reduction of food losses are global problems, both strategic and tactical approaches to research should form the core aims of the next phase of the Horticulture Innovation Lab. However, proposals accepted in the next round of applications should focus on research to accomplish practical and scalable outputs that will impact at country and then regional levels. In addition, the EET would like to see processes introduced to facilitate the transfer of technological innovations to other Feed the Future countries as soon as practicable for local evaluation and implementation.

Global issues are many but include the following that have been core to Horticulture Innovation Lab activities during the past 3.5 years.

- Improve nutrition, health, welfare and income of families through intensification of production of high value horticultural crops;
- Reduce postharvest losses and wastage in the supply chain;
- Develop sustainable and profitable production and postharvest systems with special reference to local indigenous vegetable and fruit crops;
- Capacity building of both individuals and institutions (degree of effort depends on country; should be built into every project).
- Safe fruit and vegetable production to reduce pesticide residues, preserve water quality and enhance environmentally sustainable management practices;

- Provide appropriate information and communication systems and technologies for transferring new technologies to extension officers, university faculty and smallholder farmers, especially women, using modern ICT methods.
- Water for Food – Manage water for agriculture/horticulture sustainably and more productively to enhance food security.

d. *What activities from the current Innovation Lab should be continued, refocused and/or eliminated?*

Horticultural research and development needs for developing Feed the Future countries include the following topics:

Genetic improvement. Focus should be on obtaining already available selected advanced breeding lines and cultivars from agencies such as AVRDC for vegetables and selected breeders for fruit, rather than Horticulture Innovation Lab undertaking its own breeding from scratch, that will result in improvements in productivity. The yield stability and environmental concerns can be addressed through rigorous selection for genetic resistance to diseases, pests, heat and drought. Other objectives would include nutritional enhancement in both exotic and indigenous crops of both fruit and vegetables through selection and evaluation of under utilized local vegetables and fruit.

Safe fruit and vegetable production. Objectives are to reduce pesticides, avoid heavy metal and microbial contamination while enhancing yield of quality crops. Such technologies will also protect water quality.

Horticultural systems development.
- ***Enabling institutions.*** Encourage the formation of farmer associations or cooperatives including development of credit schemes for smallholders such as the Savings Led Microfinance program (Miller, PI) through collaborating agencies such as OXFAM. Horticultural crop production is more expensive and riskier than staple crop production but the rewards per unit area of land utilized can be much greater. Information about flows of product onto the market needs to be developed so that scheduling of production can be organized to meet market demand. There is a critical need to enhance the efforts in building more human capacity with education scholarships required for MS and PhD training, both locally and in special cases to the US. In addition, institutional capacity building is needed through a range of activities to improve academic and scientific outputs and to enhance sustainable employment patterns.
- ***Seed sector development.***_Work with the private sector to overcome problems associated with lack of quality open pollinated seeds, lack of storage knowledge and poor storage facilities that lead to poor germination and poor plant stand. Scale up of the drying beads technology is required.

- ***Market systems*****.** Rapid changes in the marketing sector do occur once supermarkets enter a country, as urbanization progresses and the agri-food sector is being transformed in many Feed the Future countries. Smallholder farmers need to adapt to provide crops of the required quality produced under GAP standards; smallholder producers find it difficult to get produce to market.
- ***Postharvest facilities.*** Training of basic postharvest knowledge and tools for smallholder farmers, extension officers, junior faculty and private sector players in the value chain is an urgent requirement as horticultural crops are very perishable, cannot be stored for long and losses can be as high as 60% especially in hot humid tropical regions. Appropriate, locally adapted, economical and efficient handling, transport and marketing systems are required.
- ***Peri-urban production.*** Local production of vegetables and fruit in home gardens year-round is potentially an important way to improve nutrition of children in urban areas. Adaptive research is needed to reduce risks associated with crop contamination from dirty water, and there is a need for application of innovative small-scale technologies (clean water; irrigation; management; cultivars; fertilizers; nutrition) that could be recommended by practical horticultural expertise.

Continuation of* Horticulture Innovation Lab *projects.

- Activities should continue to be focused on the Feed the Future countries.
- Enhance efforts to select appropriate seeds and planting stock for microclimates and soils in Feed the Future countries.
- More attention should be devoted to nutrition and health of horticultural crops [such as AIVs (Weller, PI)] that form the basis of Horticulture Innovation Lab projects where applicable.
- African indigenous vegetables have dominated activities in Africa; work should continue to develop information packages for production, postharvest and processing for availability for scale up.
- Postharvest training should be continued on an ongoing basis using the PTSC in Arusha, initially. Attempts should be made to replicate such Centers in other Feed the Future countries; although it is likely that they could be organized at the Regional Centers of Innovation. This would continue capacity building to create understanding of postharvest in the value chain, present key principles and technologies as well as develop understanding of techniques to reduce losses and wastage and maintain freshness and micronutrient density after harvest.
- Eliminate further projects on floricultural crops. While flower production has the potential to increase small farmer income, and thus allow families to improve nutrition and health, because of the limited funding available to the Horticulture Innovation Lab, we recommend that future effort be directed to horticultural food crops; an exception to this would be Trellis Funds that could be used for a flower project if justified.

Refocusing of Horticulture Innovation Lab projects.

- Ensure that all funded projects have clear researchable, testable problem statements that will provide data for questions being asked.
- Ensure that all projects have an appropriate balance of plant science/horticultural science and social science (such as agro-economist, statistician, sociologist) so that properly designed production and market chain activities can be analyzed both quantitatively and qualitatively
- Seed project (Nienhuis, PI) in Central America should follow reliable accepted protocols for introduction and evaluation of new seed cultivars to new microclimates. If this cannot be refocused properly, then terminate.

Termination of* Horticulture Innovation Lab *projects

- Terminate drying beads as a priority activity. It is a high value project and it has made very good progress to date. However, it is now ready for adoption/scale up for further development by the private sector partner.

3. *What lessons learned should be taken into consideration if a second, final five year phase is awarded?*

- Increased funding should be allocated to the Horticulture Innovation Labto enable completion of existing projects and initiation of new projects in the next five year phase (25% increase suggested).
- Director of the Horticulture Innovation Lab should be a full-time appointment to enable enhanced responsibilities to be undertaken.
- The EET suggests that the ME should attempt to work with universities to develop a process whereby annual renewal of contracts and associated financial allocations are streamlined to avoid delay in advancing the funds. Too much of a delay has occurred in some projects in allocating funds to in-country PIs. (A PI should not have to wait nearly six months for funds to arrive, or pay the research costs out of his own pocket for six months.)
- The ME should be more aggressive and proactive in developing partnerships with new partners. The EET encourages the ME to continue to engage in dialogue with Missions, other Innovation Labs and AVRDC, as well as contractors such as FINTRAC, Winrock, CGIARs and NGOs. The ME should encourage the PIs of projects to develop participation with other interested partners.
- The EET recommends that ME approach other donor and partner agencies such as World Bank, FAO, IFAD, CGIAR, ODA, CTA, ADB, COL and the private sector for strengthening partnerships, especially for the Regional Centers of Innovation and supplementing available funds. This will also ensure that an increased number of horticultural students are provided with opportunities to obtain advanced degrees in various horticultural fields to strengthen the intellectual and knowledge base of the institutions. To accomplish additional capacity building there is a need to strengthen the horticultural curriculum of

the tertiary sector in Feed the Future countries in SE Asia, Africa and Central America.

- In order to develop relationships with other external agencies, some of which are indicated above, it is suggested that during the next five-year phase the Horticulture Innovation Lab devote more resources to developing collaborative relationships with appropriate partners in development. This may include some entities on the social science side of the development spectrum that have limited traditional contact with organizations such as the Horticulture Innovation Lab, which is devoted more to R&D and implementation at the smallholder farmer level.

4. *What are the opportunity costs of not continuing the research of this Innovation Lab?*
    - Relationships/contacts and collaborators gained over the past four years will be lost.
    - Visibility of the Horticulture Innovation Lab, and horticultural emphasis of the USAID program will be lost.
    - Programs abandoned before complete production and postharvest packages can be defined and delivered to smallholder farmers and to Missions for scale up; premature termination of promising programs.
    - Value of initial $15 million investment to Horticulture Innovation Lab will be markedly reduced.
    - Reputation of the Horticulture Innovation Lab and USAID would be sullied; having built up the hopes, dreams and expectations of smallholder farmers, especially women, that the horticultural projects managed by the Horticulture Innovation Lab encouraged, then termination of the program would be a devastating blow and US reputation would be irrevocably tarnished.
    - The costs of, and promise heralded with the creation of the Regional Centers of Innovation and the Postharvest Training and Services Center will be wasted if funding is not continued to undertake their exciting development and training programs.

XI. Recommendations

Recommendation 1. The EET recommends that the ME carefully consider recruiting clearly accomplished people from different horticulture specialty areas from both the public and private sector as members of IAB with no conflicts of interest.

Recommendation 2. The EET strongly recommends that the ME review the results of the survey of host country PIs in setting the research priorities and developing the future research agenda.

Recommendation 3. The ME should be congratulated for its efforts to engage with the Missions in host countries. The EET strongly recommends that the ME proactively continue the engagement with the Missions and where it is possible, inform and involve the Mission in the project review process (as requested in Cambodia) so that they feel that they have an obligation and ownership for the project. The ME also should encourage the PIs and the host country representatives to periodically meet with the Mission and apprise them of the progress of the project and showcase the significant outputs. More direct integration of Horticulture Innovation Lab research into Mission value chain projects is needed.

Recommendation 4. The EET recommends that the ME regularly invite public and private donor agencies such as FAO, World Bank, IFAD, CGIAR, Gates Foundation, and NGOs to participate in their workshops and annual meetings. In addition, the ME should regularly distribute their publications, press releases and significant findings to the above agencies so that they are aware of the accomplishments of the Horticulture Innovation Lab.

Recommendation 5. The EET recommends that the USAID AOTR serve as an intermediary between the ME and the Missions so that it can facilitate collaboration between the Horticulture Innovation Lab and the Missions.

Recommendation 6. We recommend that training efforts and appropriate workshops are built in as an integral component of most, if not all future projects, as this will facilitate both implementation and capacity building objectives.

Recommendation 7. The EET recommends that the Horticulture Innovation Lab, in conjunction with in-country collaborators, extend the postharvest training program, so successful in Tanzania, into other Feed the Future countries using the Regional Centers of Innovation as a base, and that the Regional Centers of Innovation be equipped appropriately to enable this to occur.

Recommendation 8. The EET recommends that the ME Information Management and Communications team and in particular the new communications coordinator work assiduously to develop close links with news editors in all branches of the media in order to create better opportunities for wider distribution of interesting, good news and successful stories flowing from Horticulture Innovation Lab activities. Such stories are fine to have at a local level, but they need to find places in national and international outlets.

Recommendation 9. The EET recommends that the ME Information Management and Communications team further develop social media systems for communicating messages of hope and success about the role of horticulture in reducing poverty, increasing food security, improving health and nutrition of women and children, increasing household incomes, and producing safer food and vegetables for household and market consumption.

Recommendation 10. The EET recommends that the ME Information Management and Communications team establish links with the Commonwealth of Learning to determine the processes and protocols that they are using to help smallholder farmers gain knowledge of technologies, management and markets using modern ICT technologies and determine if there is any opportunity for collaborating in selected past and present British Commonwealth countries.

Recommendation 11. The EET recommends that the current protocols and practices undertaken by the ME to ensure gender equity and inclusion on all Horticulture Innovation Lab projects be commended and that efforts be maintained to ensure that a person with expertise and experience in social sciences (such as sociology, anthropology) be included in all future project teams where practicable and on a need basis.

Recommendation 12. The EET recommends that the Horticulture Innovation Lab be renewed and continued for another five-year phase and that the ME remains at University of California, Davis for the second phase with a non-competitive renewal.

XII. APPENDICES

Appendix 1. External Evaluation Team members:

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Appendix 2.

Scope of Work: External Evaluation of the Feed the Future Food Security Innovation Lab: Collaborative Research on Horticulture[2]
Award Number: EPP-A-00-09-00004

Purpose

The purpose of this external evaluation of the Feed the Future Food Security Innovation Lab: Collaborative Research on Horticulture (hereafter referred to as the Hort Innovation Lab) is to assess the program management, research performance, and to provide recommendations on possible program direction for the U.S. Agency for International Development (USAID). This evaluation will help inform USAID on whether to extend the Hort Innovation Lab for a second, final five year phase, or end funding at the conclusion of its current five year phase.

Background

The Feed the Future Food Security Innovation Lab: Collaborative Research Programs with U.S. Universities (formerly called CRSPs) were created under Title XII of the International Development and Food Assistance Act of 1975, which authorized USAID to engage U.S. land grant and other eligible universities to address the needs of developing nations while also contributing to U.S. food security and agricultural development. In 2000, Title XII was reauthorized, enabling the continuation of the CRSPs as one of several types of U.S. university research efforts helping "to achieve the mutual goals among nations of ensuring food security, human health, agricultural growth, trade expansion, and the wise and sustainable use of natural resources".

The U.S. University led collaborative research Innovation Labs are an integral part of the new Feed the Future Food Security Innovation Center, established to respond to two key recommendations from a Board for International Food and Agricultural Development (BIFAD) commissioned CRSP review[3]:

- To develop an overarching and coordinated strategy for engaging U.S. universities in agriculture and food security research and human and institutional capacity development that includes the CRSPs as a central component; and
- To leverage the impact of CRSP investments by strengthening links across universities, U.S. government, global programs, foundations, and other donors.

The Food Security Innovation Center will enable USAID to manage its research, policy and capacity-strengthening portfolio by thematic area rather than by institutional home. To this point, CRSP programs have been renamed as Innovation Labs. This name change does not alter USAID's commitment to funding the integrated research and training exemplified by CRSPs and other types of research and capacity strengthening programs with U.S. universities. On the contrary, USAID is significantly expanding opportunities for Title XII universities and their partners to compete for cooperative grant awards in a number of the Food Security Innovation Center program areas. Each of the former CRSP programs are now included in one of the following seven Center programs:

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[2] Formerly called the Horticulture (Hort) Collaborative Research Support Program (CRSP)

[3] http://transition.usaid.gov/our_work/agriculture/bifad/BIFADREVIEW_CRSP_August2012.pdf

1. *Program for Research on Climate Resilient Cereals* – helps smallholder farmers adapt to climate change and build resilience by developing new cereal varieties with enhanced yield and tolerance to drought, heat, salinity and low soil fertility and delivering these varieties in diversified, sustainable farming systems.

2. *Program for Research on Legume Productivity* – increases the production and consumption of critical, protein-rich legumes, by developing disease and stress tolerant, high-yielding varieties, improving market linkages and postharvest processing and integrating legumes into major farming systems to improve household nutrition and incomes, especially for women.

3. *Program for Advanced Approaches to Combat Pests and Diseases* -- harnesses US scientific expertise and emerging molecular tools to develop new animal vaccines and crops and animals resistant to pests and diseases that cause significant production losses in tropical systems.

4. *Program for Research on Nutritious and Safe Foods* -- addresses under nutrition, especially in women and children, by increasing the availability and access to nutrient dense foods through research on horticulture crops, livestock, fish and dairy, food safety threats such as mycotoxins and other contaminants and on household nutrition and food utilization.

5. *Program for Markets and Policy Research and Support* -- works to achieve inclusive agricultural growth and improved nutrition through research on enabling policies, socioeconomics and technology targeting and by building the capacity of partner governments to effect sustainable change in areas such as land tenure, financial instruments, input policies and regulatory regimes.

6. *Program for Sustainable Intensification* -- works with smallholder farmers to incorporate sustainable, productivity enhancing technologies and farming practices into major production systems where the poor and undernourished are concentrated, and through intensification and diversification of these systems, to enhance resilience, nutrition and agricultural growth.

7. *Program for Human and Institutional Capacity Development* -- strengthens individuals, scientists, entrepreneurs, educators and institutions, ensuring that food and agriculture systems in developing countries are capable of meeting the food security challenge and that women especially are poised to take advantage of new opportunities and provide critical leadership in agricultural research, private sector growth, policy development, higher education and extension services.

Description of the Horticulture Innovation Lab

Purpose

The Hort Innovation Lab meets the food needs and improves nutrition and human health in the developing world, while providing opportunities for diversification of income and consequent economic and social advancement of the rural poor, particularly women, through horticulture development. The results of research and training activities increase food security and improve the quality of life of people in developing countries while bringing an international focus to the research, teaching, and extension efforts of U.S. institutions. The Hort Innovation Lab builds capacity at national research institutes, trains farmers and horticultural stakeholders in improved practices, links farmers to markets and develops a range of innovative technologies aimed at significantly improving the profitability of horticultural production in over 30 countries throughout Africa, Central America, and Asia.

2012 Activities

The cultivation and marketing of high-value fruit, vegetable and flower crops—horticulture—offers the promise of increased incomes and enriched diets for both growers and consumers in developing countries. To that end, the Hort Innovation Lab builds international partnerships for fruit and vegetable research that improves livelihoods in developing countries. Successful horticulture is heavily knowledge-dependent, therefore the Horticulture Innovation Lab partners with organizations in three different ways to build capacity while supporting research outcomes. First, the Hort Innovation Lab supports research projects led by top U.S. public university scientists with international collaborators that solve horticultural problems along the value chain. In addition to research projects, the Hort Innovation Lab has established three Regional Centers of Innovation—one in Thailand, Honduras and Kenya—each of which supports horticulture at existing international research centers with a multi-country reach. Finally, Hort Innovation Lab is building capacity among smaller organizations in the developing world and U.S. graduate students, through projects that pair the two together for mutual benefit.

2012 Geographic focus

Feed the Future Countries: Guatemala, Haiti, Honduras, Nicaragua, Bangladesh, Nepal, Cambodia, Ghana, Kenya, Malawi, Rwanda, Tanzania, Uganda, Zambia

Non-Feed the Future Countries: Bolivia, Chile, Costa Rica, Dominican Republic, Benin, Democratic Republic of Congo, Gabon, India, Laos, Panama, Sri Lanka, Thailand, Vietnam, Mexico, Nigeria, South Africa, Zimbabwe

Status of Cooperative Agreement

An Associates Cooperative Agreement with Leader was awarded to the University of California, Davis as the Management Entity (ME) for the Hort Innovation Lab. The Hort Innovation Lab is in its fourth year of its first five year phase which ends on September 30, 2014. For this fourth year, $3,000,000 was added to the Cooperative Agreement. The Hort Innovation Lab is one of ten Innovation Labs conducting collaborative research with eligible U.S. Universities[4] that are supported by USAID's Bureau for Food Security.

Additional information on the Hort Innovation Lab can be found on their web site: http://hortcrsp.ucdavis.edu.

Scope of Work

[4] Eligible universities are land-grant universities, sea-grant colleges, Native American land-grant colleges and others as spelled out in Section 296(d) of Title XII. Ineligible universities and colleges cannot respond to the RFA but can participate as a partner.

This evaluation will provide USAID and the ME with constructive feedback on the past research performance and management of the Hort Innovation Lab. Furthermore, since this Innovation Lab will be completing its first five year phase in the near future, the External Evaluation Team (EET) should take a forward looking view and provide recommendations if a second, final five year phase should be awarded. If recommended, suggestions should be provided on the research focus of a second phase.

Specifically, the EET will: A) assess the management of the Hort Innovation Lab by the ME, B) evaluate the research program focus and outputs against the stated research and development program, C) consider how the research program is aligned with Feed the Future research priorities, D) assess the level and effectiveness of human and institutional capacity building, E) examine how collaboration, outreach and technology dissemination is accomplished and its results, F) explore how gender is incorporated into the research and capacity building programs, G) assess the degree and adequacy of project level monitoring and evaluation, and H) recommend if a second, final five year phase should be awarded and what it's research focus should be in accordance with the Feed the Future Food Security Innovation Center programs.

A) Management

Technical leadership

1. What are examples of technical leadership displayed by the ME?
2. How well has the ME balanced research, implementation activities, training and capacity building given the amount of funding provided?
3. How has the ME built on earlier investments? What can be done to capitalize on these to broaden or accelerate progress?
4. How does the ME continue to be forward thinking about research ideas and plans?
5. How has the ME promoted and maximized values such as collaboration, capacity building and outreach among sub-awardees?
6. Has the ME developed mechanisms to ensure that local, national and regional needs and priorities will continue to be incorporated into the development of the research agenda? What are these mechanisms?
7. How well has the ME facilitated the participation of new partners?
8. How has the ME engaged USAID bilateral Missions, other donors and partners (i.e. World Bank, IFAD, FAO, CGIAR, NGOs, the private sector) in the Innovation Lab's research and capacity building activities? Give examples. How might engagement be increased?

Administration

1. What systems are in place to keep research activities on track according to program goals?
2. What are the roles and functions of advisory committees? Have they been effective and efficient?
3. What major challenges has the ME faced and how have they been addressed? Give examples.
4. How have administrative/management problems been resolved by the ME? Give examples.
5. In general, what has been the management style of the ME regarding principle investigators and sub awardees? Are there any areas that could be improved?
6. Is the administrative cost of the Innovation Lab appropriate for its size? Is the present structure cost effective and efficient?
7. Has communication by the ME with collaborating partners been effective?

Financial management

1. How well has the ME managed the financial aspects of the Innovation Lab? Are the U.S. and host country collaborators satisfied with financial management by the ME? How have problems been resolved? Give examples.
2. How is project resource allocations made? Is the allocation appropriate?
3. Has the system for reimbursement of expenditures been efficient for all collaborators? What areas need to be improved to address pipeline issues or payment lags?
4. Has cost matching requirements been met by all partners? What has been the effect of these requirements?

USAID's role

1. What has been the involvement and contribution of the USAID Agreement Officer's Technical Representative (AOTR)? How can it be improved?
2. How have changes in USAID priorities impacted the management and administration of the Innovation Lab? Give examples.

B) Research program focus and output

13. Are the depth, breadth and rigor of the research and development activities sufficient to achieve stated program goals and objectives? How could the major themes or topics be refined to increase impact?
14. Is the approved research program funded appropriately? What should be changed?
15. What have been the significant accomplishments in terms of research and technology dissemination?
16. Among the projects making significant progress, which ones are scalable for a greater impact?
17. What activities have not been as successful as planned and why?
18. In what ways are the research activities strategically sequenced to ensure targeted development outcomes within a known period?
19. How does the ME ensure that research activities or themes supplement and not duplicate other development initiatives in the regions where the Innovation Lab is active?
20. Do research goals have national policy implications? If so, how are they addressed? Give examples.
21. What was the process for sub-award selection? How effectively did the process yield a high quality, relevant portfolio of activities?
22. Assess the balance of domestic versus overseas research in terms of effectiveness of solving constraints in developing countries. Are changes needed in the balance?
23. How has the United States benefited from the Innovation Lab's research? Give examples.
24. How much emphasis should occur within the Innovation Lab portfolio on basic research, applied research, implementation, and human and institutional capacity building?

25. How does the Innovation Lab respond to the Title XII "Famine Prevention and Freedom from Hunger" Amendment to the Foreign Assistance Act of 1961?[5]

C) Alignment with Feed the Future research priorities

3. How has the Innovation Lab aligned with Feed the Future research and development priorities? Give examples. In what areas has the Innovation Lab not aligned with Feed the Future priorities and why?
4. How well does the Innovation Lab research and capacity building activities fit under one or more of the seven programs of the Feed the Future Food Security Innovation Center? What are the relevant program areas? How can this fit be improved?

D) Human and institutional capacity building

1. How has the Innovation Lab been effective at building the capacity of host country researchers, policymakers and practitioners?
2. How has a pipeline of students been cultivated for long-term degree training opportunities?
3. Has the program been successful in selecting the right mix of students from appropriate institutions? Are these trained students returning to their home countries to continue work in their trained fields?
4. Compared to the research activities, what has been the level of effort and investment in training and institutional capacity building? Is it sufficient?
5. Should there be greater focus on institutional capacity building? If so, in what areas?
6. How can impact of institutional capacity building be captured and measured more effectively?

E) Collaboration, outreach and technology dissemination

1. What outreach strategies have been integrated into project design to increase likelihood of uptake and utilization of research results? What have been the most effective strategies for outreach at the country level?
2. How have research outputs been disseminated at the regional and global level? What tools have been used (i.e. hosted events, publications, web sites) and how effective have they been? Give examples.
3. Does the Innovation Lab have a plan for technology dissemination? What is it?
4. Evaluate the dissemination of research results and the effectiveness of their utilization as a measure of the appropriateness of the research.
5. Has the Innovation Lab partnered with the right collaborators to implement and disseminate the outputs of the research program? Who else should they partner with?
6. Are there any unexplored areas of collaboration between projects that are feasible and have potential? Give examples.

F) Gender inclusion

1. Does the Innovation Lab have a formal plan for gender inclusion in all of it activities?

[5] http://www.aplu.org/page.aspx?pid=587

2. How has gender been taken into consideration in research design, training and outreach strategies? What have been the results? What areas could be improved and how?

G) Monitoring and evaluation

1. What types of monitoring and evaluation have been undertaken by the ME? Are social scientists used to conduct broad impact assessments?
2. Are the indicators used effective at capturing and communicating the outcomes and impacts of research activities? Are there appropriate indicators for each stage in the "research continuum"? Have indicators capturing impacts and outcomes on higher levels been developed?
3. Have baselines been established? If not, why?
4. Are data collected valid and of proper quality for reporting?

H) Research focus of a second, final five year phase if awarded

1. Do the results achieved to date justify awarding a second, final five year phase of the Innovation Lab in the same research area? Why or why not?
2. If a second five year phase is funded:
    a. What should be the research focus?
    b. Should there be an emphasis on fewer high performing activities?
    c. Should the research focus be on one or both of the following, as recommended by the *BIFAD Review of Collaborative Research Support Program (CRSP) Model: A Report Commission by BIFAD at the Request of USAID, August 2012*:
        i. Strategic research on a global problem,
        ii. Demand driven research to enhance food security at the country and regional level.
    d. What activities from the current Innovation Lab should be continued, refocused and/or eliminated?
3. What lessons learned should be taken into consideration if a second, final five year phase is awarded?
4. What are the opportunity costs of not continuing the research of this Innovation Lab?

Evaluation Methodology

The evaluation will be based the following: A) a desk review of Hort Innovation Lab project documents, publications and web sites, B) telephone conference call with the USAID AOTR and other relevant USAID officers, C) telephone conference call with ME staff, D) telephone interviews with Innovation Lab principal investigators and stakeholders, E) a survey of host country principle investigators, ; and F) international travel[6] by the EET to visit host country partner programs. Specifically, the EET will do the following:

A) Desk review

The EET will review key Hort Innovation Lab documents including, but not limited to, the Leader Cooperative Agreement, annual reports, work plans, program operation documentation, funded

[6] All domestic and international travel arrangements, including airfare, are to be handled by the U.S. Department of Agriculture/Foreign Agriculture Service/Office of Capacity Building and Development Resources and Disaster Assistance and must be in accordance with U.S. Government travel regulations.

research proposals, a list of principal investigators and key stakeholders, and Innovation web sites. The material will be made available by the AOTR and the ME. The purpose of the desk review is to provide background, context and determine necessary interviews and travel sites to successfully complete the Evaluation.

B) Conference call with USAID

The EET will schedule a conference call with the USAID AOTR or their representative and other USAID staff as deemed necessary after a preliminary desk review. This call will be informational to discuss USAID's role in the funding and management of the Innovation Lab and to answer questions concerning the implementation and delivery of the Evaluation.

C) Conference call with Management Entity

The EET will schedule a conference call with the ME which includes the Innovation Lab Director and other key staff, to discuss the ME's responsibilities, request needed information and answer questions. The ME serves as the lead U.S. University for the Innovation Lab and is responsible for program implementation, financial and administrative management, reporting and quality of research results.

D) Telephone interviews with principle investigators and other stakeholders

The EET will select no less than six principle investigators and stakeholders combined to interview over the telephone. The purpose of these interviews is to help gather the needed information to answer the questions listed above in the Scope of Work.

E) Survey of host country principle investigators

The EET should use an internet-based survey of host country principle investigators. The survey has been developed by Dr. Timothy Dalton of Kansas State University and used in three previous Innovation Lab external evaluations. The survey will be provided to the team by the USAID evaluation manager. The EET can modify the survey as needed to make it relevant for the Hort Innovation Lab evaluation. The survey results will be tallied by Dr. Dalton and provided to the EET.

F) Visit to host country partners

Based on the above telephone consultations and interviews, the EET will determine which host country partner programs would be most advantageous to visit. The purpose of these visits will be to gather the needed information to answer the questions poised above in the Scope of Work. No more than two international trips are to be made (one EET member per trip only).

<u>Evaluation Report</u>

The evaluation report will be a synthesis of the topics and questions outlined in this Scope of Work. The EET may include other topics that are deemed relevant. The report should also discuss the merits of granting the Hort Innovation Lab a 5-year funded extension and what the research focus should be.

The report may be submitted in any format that effectively addresses the substance of this Scope of Work. The report should include the following components:

Title Page
Table of Contents

List of Acronyms
List of Tables
List of Figures
Executive Summary
Synthesis of Findings and Conclusions Regarding:

- Program Management
- Research Performance
- New Innovation Lab Development

Recommendations
Appendices

A. Statement of work
B. Itinerary
C. List of persons contacted
D. List of materials reviewed
E. Locations and dates of field visits
F. Survey results

A draft report will be submitted electronically in MS Word format to the USAID Evaluation Manager by May 10, 2013. USAID will review the draft and return comments and suggestions for consideration to the EET by May 24, 2013. The final report should be submitted to USAID by June 7, 2013. All USAID comments should be sufficiently addressed in the final report. An oral presentation of the final report may also be requested by USAID via conference call at a mutually agreed time in June 2013. USAID will share the draft and final reports with the Innovation Lab ME. The final report will be made publicly available.

Level of Effort and Time Frame
The level of effort for the entirety of this Scope of Work will consist of no more than 30 billable days for the Team Leader and 25 billable days for each of the other EET members. All billable work is to be performed between March 1 and June 7, 2013. The USAID evaluation manager will be made available to the EET as a resource person but will not contribute directly to the preparation of the report.

Team Composition and Qualifications
The technical qualifications of EET members must be matched with the technical areas of focus of the Hort Innovation Lab. Team members must have the expertise necessary to evaluate the Innovation Lab and to address the questions in the Scope of Work. Team members must familiarize themselves with USAID's priorities and objectives in the economic growth sector and particularly the Feed the Future research strategy. USAID will designate one team member as the Team Leader.

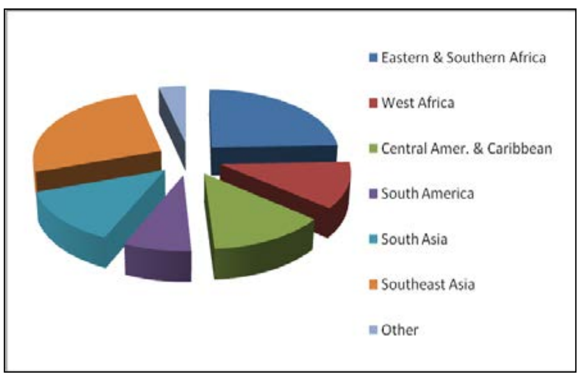
Administrative/management member (1): A senior administrator with a minimum with ten years of experience managing multifaceted international development research and/or university-based programs. The preferred candidate will be familiar with both university-based programs and USAID (or other donor) funded programs. A background in agricultural development is preferred. The candidate would also have: a) demonstrated capacity to conduct program evaluation; b) an understanding of USAID's foreign assistance goals, and its particular objectives related to collaborative research, agricultural development and food security; and c) the ability to analyze issues and formulate concrete recommendations orally and in writing.

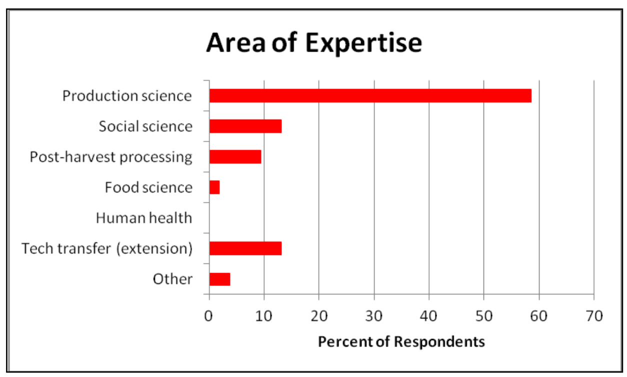
Technical team members (2): Must be recognized experts in international development related to agriculture with specific expertise in horticulture. Team members will be chosen from those who have experience in such areas as sustainable agriculture production, agricultural economics, and/or natural resource management. Technical team member candidates will also have demonstrated the following: a) the capacity to conduct program evaluation; b) a thorough understanding of research methodology; c) experience in effectively conducting outreach and dissemination to policymakers, development practitioners and/or the private sector; and d) the ability to analyze issues and formulate concrete recommendations orally and in writing.

Appendix 3. Summary of Responses to the AXIO SURVEY for Host Country Participants Involved in the Horticulture Innovation Lab

The questions for the AXIO survey were developed by Drs. Grusak, Hewett, and Shanmugasundaram. With the help of Dr. Timothy Dalton (Kansas State University) the survey instrument was constructed and a request to complete the survey was sent to 117 potential host country respondents. Fifty-six people started the survey and 46 people completed it (i.e., all the way to the last question). There were 26 questions in the survey; respondents were given an opportunity to provide comments for most of these questions. Interestingly, the average time to complete the 26 questions in the survey was over 8 hours. This suggests respondents were either thinking about answers and coming back to the survey later, or perhaps were dealing with poor/intermittent internet connections. No matter the reason, many respondents provided comments, in addition to the check-box selections; thus, the survey appeared to provide a robust set of answers and information.

Characteristics of the Respondents
Of the 56 who started the survey, 55 were engaged in some collaborative research/development activity with the Horticulture CRSP. Respondents were well distributed between Africa (36%), Central and South America (21%), and South/Southeast Asia (40%).

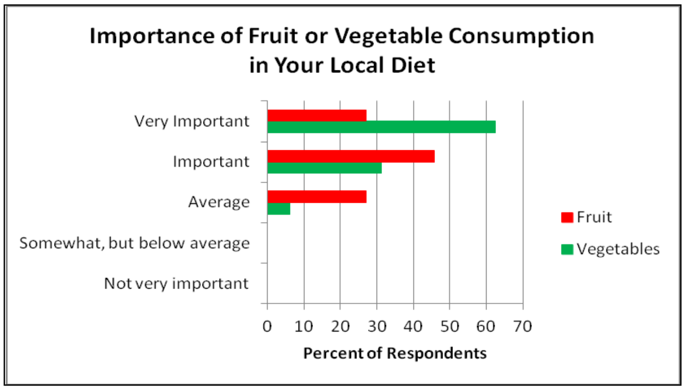




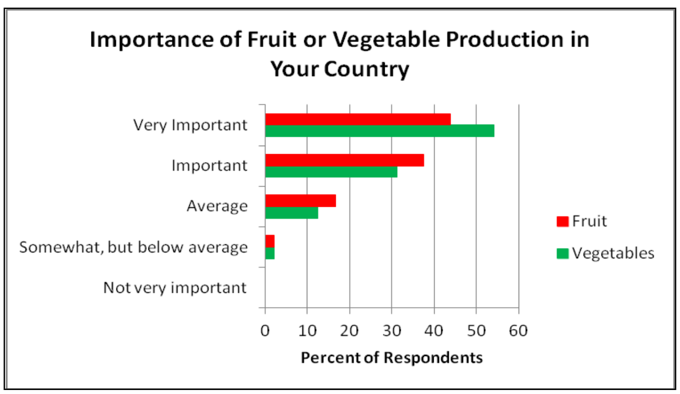
Most respondents were engaged in some aspect of production science (55%), with social science, technology transfer (extension), and postharvest science being practiced by 9-13% each. Poorly represented were respondents acknowledging expertise in food science (1 of 56) or human health (0). Note that 'Food Science' was also stated to include: nutrition, food safety, and new product development.

Fruit and vegetable perspectives
Keeping in mind that these are composite results from all regions, where fruit and vegetable intake/availability may vary, it was interesting to note that more respondents chose "very important" as the top choice (63%) for the importance of vegetables in their

local diet, whereas “important” (46%) was the top selection for the importance of fruit in the local diet.



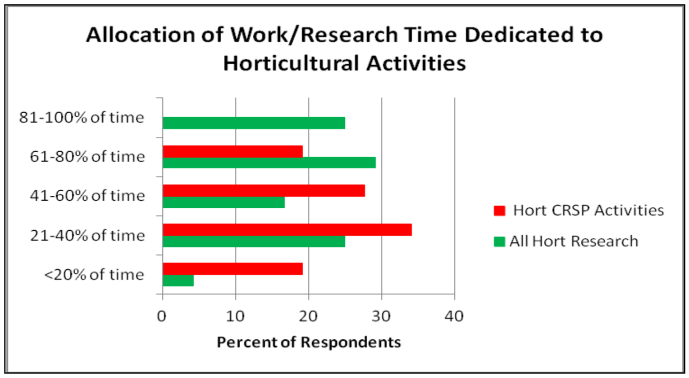
Nonetheless, when asked whether the production of vegetables or fruit were important in their country, “very important” was the top choice for both vegetables and fruit.



Furthermore, horticultural trade (with other countries) was believed to be “important” to “very important”, and a strong majority (77%) believed it was “very important” for horticultural activities to continue to grow over the coming 5 years.

Allocation of Time and Funding

Several questions were designed to understand the extent to which the survey participants were engaged in any horticultural activities (more broadly) and Horticulture CRSP activities (more specifically). Most respondents (96%) acknowledged that from 20% to 100% of their time was engaged in horticultural research activities. Time allocated specifically to Horticulture CRSP activities was skewed downward, with a range from <20% to 80%.



Furthermore, a majority of respondents (53%) indicated that Horticulture CRSP funding contributed <20% to 40% towards their annual research budget. It would appear that this group of participants is actively engaged in some aspect of horticulture research, with additional funding coming from one or more other sources, and that the Horticulture CRSP funds are adding to their overall research portfolio. This would appear to be a good sign, as it suggests that active, appropriate individuals are being engaged as partners by the Horticulture CRSP team.

Gender Integration

Almost 90% of the respondents indicated that a gender integration strategy had added value to their project's development and implementation. Thirty-seven respondents provided comments on this topic. While several issues were raised, there was a very strong recognition for including women in program activities. Their role in the horticultural trade was recognized, as was the fact that their standing in some societies limited their opportunities for decision-making or entrepreneurial possibilities. Nonetheless, several respondents acknowledged that women brought ideas and value to their projects. Contributions of men were also recognized. It would appear that all participants were attempting to do what they could in terms of gender integration.

At the same time, most respondents (81%) indicated that no funds were specifically allocated for gender integration activities/interventions. It would appear from the comments provided (17) that gender issues are ingrained in their activities, even without direct funding. This was evidenced by the involvement of women farmers or female students in various programs. Interestingly, this level of "gender integration" would have no inherent added costs. Nonetheless, many host country participants were interested in expanding activities toward gender-based issues (predominantly women focused) and indicated that they would like to see direct allocations for this in their budgets.

Nutrition and Health

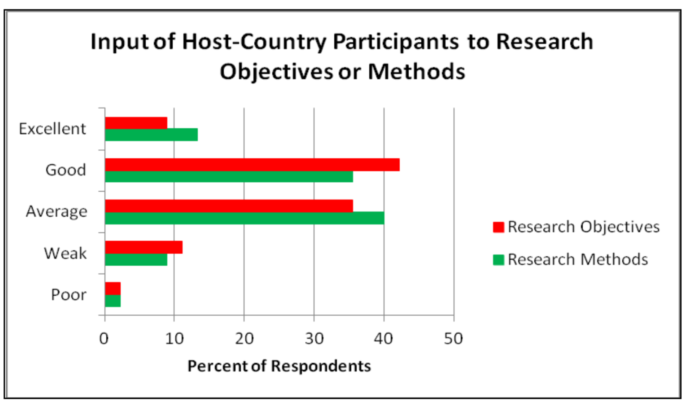
When asked if there was a specific allocation of funds for nutrition or health activities, 69% of those who provided a response said "no". Amongst the 13 comments provided, there was general agreement that nutrition/health issues should be incorporated into the Horticulture CRSP. However, the nature of what was meant by nutrition or health was quite diverse. Comments ranged from: the reduction of pesticides to help farmer's health, to a focus on nutritional quality of fruit/vegetable products, to the improvement of "quality" with better postharvest practices, to improving general nutrition of consumers by having more fruit/vegetables available. It seems that the development/incorporation of future health and nutrition activities in the Horticulture CRSP may require some thoughtful attention to what this topic might include. Some education of the project participants regarding helth/nutrition issues, along with the inclusion of more food science, nutrition, or health science participants are probably warranted.

Impact Assessment

Slightly more than half of the respondents indicated they were carrying out an impact assessment. Comments given on this topic (23) suggested there were differing levels of attention to this, with some assessments perhaps more formal and others more of a cursory nature. No strong sense of what respondents thought about impact assessment (e.g., was it worthwhile) could be drawn from the comments. There also seemed to be some differences in the understanding of what an impact assessment was.

Involvement of Host Country Participants in Project Leadership

Most respondents indicated that their involvement in setting research objectives, hypotheses, or goals was average to good. Twelve comments were given on this topic; these ranged from: being given the project as a sub-contract, to being the lead collaborator. Most responded that they had at least some input. Similarly, a majority of the respondents indicated that their input into research methods was average to good. Nine comments on this topic ranged from: being given the methods, to being the lead on methods; however, most comments seemed to indicate that the host country participants were highly involved with decisions on research methods.



On the topic of writing research papers or project reports, most respondents appeared to have had some level of involvement with this. About 7% of those who answered this question indicated that they initiated the writing, while 16% indicated no involvement in writing reports or papers.

Suggestions for Improvement and Future Work

Sixteen comments were provided on the topic of "how to improve your research and development collaboration". The main thrust of these were requests to improve communication (four comments), presumably with US PIs, and especially more face-to-face interactions (three comments). There were also requests for more expertise to support project activities and to ensure achievement of goals (two comments). Apparently, this epertise was not available from the US PI institution, or was not being provided by the US institution. Two comments were also made concerning more private sector interactions.

When queried about the importance of each respondent's Horticulture CRSP project to local or national research priorities, over 80% of those who responded selected the choice: "important" or "very important". Respondents were asked to provide up to five research projects for their region, which they thought the Horticulture CRSP should fund. Answers varied, but the following list captures many ideas that were received by multiple individuals:

- Mitigation of climate change-related effects on horticultural production
- Improving postharvest technologies
- Reducing pesticide use
- Conserving horticultural genetic resources
- Expanding the use of underutilized crops
- Improving seed systems and improving responsiveness to farmer needs
- Food security, safety, nutrition, and health
- Breeding activities
- Methods for disease/pest surveillance

Respondents were also asked to provide up to five priority vegetables for their region, for which they thought the Horticulture CRSP should provide funding. Answers varied, but the following list captures many listings that were received by multiple individuals:

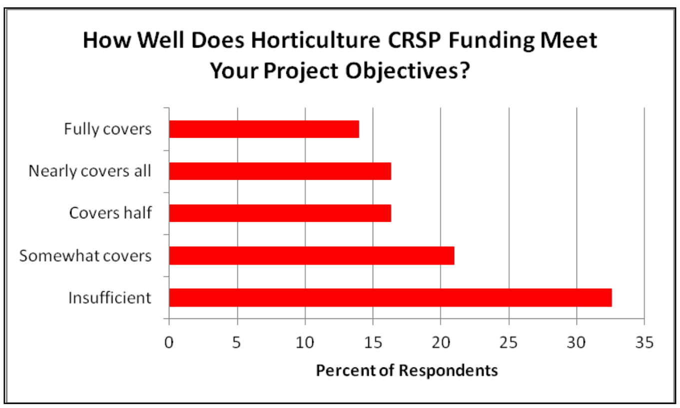
- Tomato
- Various leafy vegetables (including indigenous species)
- Onion
- Pepper
- Potato
- Sweet potato
- Cucumber
- Vegetable legumes

Respondents were asked to provide up to five fruit for their region, for which they thought the Horticulture CRSP should provide funding. Answers varied, but the following list captures many listings that were received by multiple individuals:

- Banana

- Mango
- Orange/other citrus
- Papaya
- Avocado
- Passion fruit
- Guava
- Apple
- Melon
- Passion fruit
- Strawberry
- Pineapple

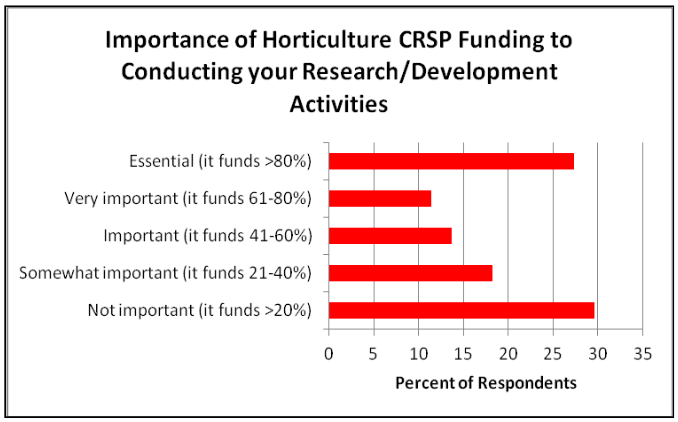
Finances and Administrative Reporting
It was interesting to note that only 14% of respondents indicated that the funds allocated to them were sufficient to cover all the costs of their proposed objectives. In other words, a majority of respondents (86%) reported that Horticulture CRSP funding was insufficient to meet the project objectives, with 33% suggesting that the allocated funds covered less than 20% of the project costs.



It is not clear why there was such disconnect between proposed objectives and the (presumably) agreed upon budgets – at least from the viewpoint of the host country collaborators. Were some of the uncovered costs related to salaries that were covered by host country institutions? Were unforeseen expenses encountered during the course of the work? Were PI and cooperators setting unrealistic work plans for the budget that was available? Were PI and cooperators using poor judgement in the establishment of their budgets? Similarly, it is not clear who oversaw the establishment of these budgets. Was it merely left up to the US PI's, or were host country budgets reviewed by the ME to ensure sound budgeting before projects began? And as follow-up to this, one wonders to what extent the ME took the available budgets into account when the progress or success of a project was being reviewed?

Eighteen comments were submitted on the topic of finances: these comments were quite varied in nature, mostly reiterating that funds were insufficient to cover all their needs. One individual provided a very lengthy critique of the two Continuation Projects that were funded at $USD 1 million each. The question was raised as to whether moving from 30 small (50K/year) projects to just two large projects was a justifiable strategy for the Horticulture CRSP program.

The question “How important is Horticulture CRSP funding to conducting your research and development activities?” yielded nearly equal rates of response between “essential” and “not important”.



The difficulty of complying with financial reporting requirements, or complying with administrative requirements (related to USAID guidelines) was about average for most respondents.

Finally, eighteen comments were provided relative to financial issues. Most of those mentioned were problems pertaining to delayed release of funds. The fact that only a portion of the funds were released up front was also noted to cause difficulties in executing projects. However, some individuals commented that there were no problems with financial management.

Appendix 4. Itineraries

2/26/2013	Teleconference with USAID team members-Carole Levin, John E. Bowman, Saharah Moon Chapotin, Angela Records and EET members-Errol Hewett, Mike Grusak and S. Shanmugasundaram. Discussion on logistics, travel, and review process
3/10/2013	Informal discussion with Elizabeth Mitcham, Amanda Crump and Jim Hill in University of California, Davis.
3/11/2013	University of California, Davis. Discussion with Elizabeth Mitcham, Amanda Crump, Mark Bell, Paul Marcotte (via conference call), Brenda Dawson and Diana Puccetti- Overview of Horticulture Innovation Lab, EET web site, printed materials and discussion. Financial management with Heather Kawakami and Sabrina Morgan and Elizabeth Mitcham. Jim Hill about University of California, Davis relations. Ken Bradford and Kate Snow PIs from University of California, Davis on their projects and Horticulture Innovation Lab
3/12/2013	Meet with David Miller, (PI) EET member joins teleconference with Amanda Crump, Mark Bell (Information management. Michael Reid and Britta Hansen via teleconference discussion on Regional Center of Innovation in Honduras. Meet with Alan Bennett, PI
3/13/2013	Sundar and Errol closing discussion with Amanda on travel plans to Asia and Africa. Sundar leaves for NJ. Errol discusses with Elizabeth Mitcham. Discussion with Brenda Dawson.
4/3/2013	Errol and Sundar arrive Phnom Penh, Cambodia.
4/4/2013	Ms. Neda Yousefian, Frederick Sagemuller, picks up Errol and Sundar and visits OU Rumcheck village. Mr. Lor Lytour, Assoc. Prof. Thong Kong, Mr. Borarin Buntong, Mr. Tho Kim Eang, accompanied us. Visited farmer's field. Sequential planting of vegetables. Observed savings group meeting. Visited Royal University of Cambodia. Met with Vice Rector Dr. Men Sarom. Discussed postharvest project. Discussion on safe vegetable project
5/4/2013	visit OXEAM and met Brian Lundand discussed savings linked microfinance. Visited USAID Cambodia Mission. Met with Dr. Kimberly Lucas, Mr. William Bradley, Mr. Teffera Betru and Mr. Sak Sambath. Discussed HarvestPlus and Horticulture Innovation Lab
6/4/2013	visit vegetable market in Phnom Penh and travel to Hanoi, Vietnam
7/4/2013	Report writing
8/4/2013	Met with Dr. Vong, Ms. Do trinh Luong, and TV crew. Visited Dong Xuan Commune in Soc Son District. Farmers training by themselves on EMINA production, Photovoice, Visit farmers field and observe safe cucumber production using bio-fertilizer and bio-pesticide. Visit with farmers and commune staff. Visit Hanoi University of Agriculture. Visit Dr. Paull's postharvest training project. Discussion with postharvest staff.
9/4/2013	Travel to Bangkok, Thailand
10/4/2013	Visit Regional Center of Innovation at Kasetsart University, Bangkok,Thailand. Meet with the Director of Regional Center of Innovation, Dr. Poonpipope Kasemsap. Visit the postharvest Lab of Dr. Jingtair and Dr.

Kietsuda at Kamphaengsaen campus of Kasetsart University. Meet Dr. Robert Holmer, AVRDC Regional Office and visit their cucurbit field and nutritional garden

11/4/2013 Visit Rhino Research Group (VCentor Thai) Drying Beads project (Bradford, PI). Met with Johan Van Asbrouck, Patcharin Tridno (Ann), Bart Schatteman and Ganesh Shivakoti from AIT. Errol left for airport in the afternoon for New Zealand.

12/4/2013 Sundar left for NJ

30/4/2013 Errol, Sundar and Mike left for Kilimanjaro, Tanzania

1/5/2013 Arrived Arusha late at night

2/5/2013 Visit AVRDC Regional Center fields and the PTSC. Meet with Dr. Ngoni Nenguwo, Dr. Fekadu, FufaDinssa, Mr. Hassan Mndiga, Dr. Tsvetelina Stoilova and Ms. Nadine Kwazi. Postharvest training activities and African indigenous vegetables and seed storage facilities.

3/5/2013 Visit Africa Technical Research Center and the mosquito Net factory. Discussion with Dr. Johnson Odera and observe his low-cost net for safe vegetable production. Discussion with AVRDC staff

4/5/2013 Report writing

5/5/2013 Leave for Nairobi, Kenya and arrive Safari park Hotel, Nairobi, Kenya

6/5/2013 Horticulture Innovation Lab annual meeting

7/5/2013 Horticulture Innovation Lab annual meeting

8/5/2013 Horticulture Innovation Lab annual meeting

9/5/2013 Grand Opening of Regional Center of Innovation at FPEAK in Thika

10/5/2013 Report writing and depart for home

11/5/2013 to 24/5/2013 Report preparation

Appendix 5. List of Persons Contacted

1. University of California, Davis, CA, Horticulture Innovation Lab.

Dr. Elizabeth Mitcham, Director
Ms Amanda Crump, Associate Director
Ms. Diana Puccetti, Office and Event Planning Assistant
Ms. Britta Lilley Hansen, Regional Center of Innovation Specialist (via telephone)
Ms. Brenda Dawson, Communications Coordinator
Dr. Michael S. Reid, Leader, Technology Innovation (via telephone)
Ms. Heather Kawakami, Budget Analyst
Ms. Sabrina Morgan, Budget Analyst
Dr. Mark A. Bell, Leader, Information and Communication
Dr. Kent Bradford, PI
Mr. G. David Miller, Co-PI
Dr. Alan Bennett, PI
Ms. Elana-Peach-Fine, Graduate Assistant
Ms. Kelsey Barale, Grafuate, Intern
Dr. James Hill, Assoc. Dean, University of California, Davis
Dr. Kate Scow, PI
Dr. Paul Marcotte consultant (Via telephone)

2. Phnom Penh, Cambodia

Mr. Borarin Buntong, postharvest, RUA
Mr. Lor Lytour, Vice Dean, RUA
Mr. Thong Kong, Ass. Prof. RUA
Prof. Dr. Men Sarom, Vice Rector, RUA
Mr. Tho Kim Eang, Lecturer, RUA
Mr. Chuong Thart, Project Coordinator, RUA
Mr. Brian Lund, Regional Director, OXFAM
Dr. Kimberley Lucas, Director FSE USAID
Mr. William Bradley, Agricultural Officer, FSE USAID
Mr. Teffera Betru, Agricultural Officer, FSE, USAID
Mr. Sak Sambath, Agricultural Economist, FSE, USAID
Mr. Frederik Sagemueller, Horticulture Innovation Lab
Ms. Neda Yousefian, Horticulture Innovation Lab

3. Hanoi, Vietnam

Dr. Nguyen Quoc Vong, HUA
Dr. Nguyen Thi Bich Thuy, HUA
Dr. Pham Thi Huong, HUA
Ms. Do Trinh Luong, Duc Trung Co., Ltd.
Ms. Pham Hoai Quyen, VTC 10 TV

Dr. Vu Kim Oanh, HUA
Nguyen Thu Huong
Pham Ngoc Hung
NguyenTrong Thang
Pham Bao Duong
Dang Xuan Phi
Tran Thi Nhu Ngoc
Pham Van Hung
Do Truong Lam
Chu Duc Tuan
Dr. Vu Thi Kim Qanh
Mr. Xuan Lie, Leader of the Dong Xuan commune
Mr. Lien, leader of the Dong Xuan cooperative
Also met 24 farmers

4. Bangkok, Thailand

Dr. Poonpipope Kasemsap, Director, Regional Center of Innovation
Dr. Thammasak Thonghet, Assoc. Prof. KU
Dr. Jingtair Sirapanich, Professor, Postharvest Technology Center
Dr. Kietsuda Luenguwilai, Researcher, Postharvest Technology Center
Dr. Teeranud Romphophak, Researcher, Postharvest Technology Center
Dr. Peerapong Sangwanangkul, Researcher, Head Assistant, Postharvest Technology Center
Mr. Siwalak Pathaveerat, Asssitant Professor, Agricultural Engineering Department.
Dr. Robert Holmer, Director, AVRDC Regional Center
Mr. David Brar, Project Manager, Toshuva Agricultural Projects
Mr. Johan van Asbrouck, Rhino Research (Centor Thai)
Ms. Patcharin Taridno (Ann), Rhino Research (Centor Thai)
Mr. Bart Schatteman, Rhino Research
Dr. Ganesh Shivakoti, Professor, AIT

5. AVRDC, Arusha, Tanzania

Dr. Ngoni Nenguwo, PTSC, AVRDC, RCA
Dr. Tsvetelina Stoilova, Genetic Resources, AVRDC RCA
Dr. Fekadu Fufa Dinssa, Vegetable Breeder, AVRDC RCA
Mr. Hassan S, Mndiga, Training and Outreach Coordinator, AVRDC RCA
Ms. Nadine Kwasi, Executive Assistant, AVRDC RCA
Dr. Rajendran Srinivasulu, Postdoctoral Economist, AVRDC RCA

6. African Technical Research Center (ATRC)

Dr. Johnson O. Odera, Director, (ATRC)

7. Nairobi, Kenya

Dr. John Bowman, Senior Agricultural Advisor, USAID (AOTR)
Dr. Angela Records, Research Fellow, USAID
Dr. Lusike Wasilwa, Assistant Director, KARI and Director, Regional Center of Innovation, Kenya
Ms. Grace G. Kithusi Kyallo, Ag. Manager, Horticultural Crops Authority
Dr. George Wilson, IAB
Dr. J.D.H. Keatinge, Director, AVRDC, IAB
Dr. Josette Lewis, Chair, IAB
Dr. Norman E. Looney, IAB
Dr. Stephen Weller, PI, Purdue University
Dr. Robert Paull, PI University of Hawaii
Dr. Steve Yaniek, Professor and Head, Dept. of Entomology, Purdue University
Dr. Maria I. Marshall, Small Business Development, Purdue University
Dr. Jim Simon, Rutgers State University, PI
Dr. Eunice Bonsi, Tuskegee University, PI
Dr. Jeffrey LeJeune, Ohio State University, PI
Dr. Vance Baird, MSU, PI
Dr. James Nienhuis, University of Wisconsin, PI
Dr. Dianne Barrett, University of California, Davis, PI
Dr. Cary J. Trexler, University of California, Davis, PI
Dr. Julio Lopez Montes, Zamorano University, Director, Regional Center of Innovation
Ms. Mary Onsongo, USAID/East Africa
Ms. Margaret Hutchison, University of Nairobi
Ms. Monicah Waiganjo, KARI
Mr. Stephen Mbithi, FPEAK
Mr. Ian Chesterman, FINTRAC
Ms. Millie Gadboi/USAID/Kenya
Dr. Linus Opara, IAB
Dr. Thibaud Martin, CIRAD

Appendix 6. List of Documents Reviewed/Consulted

Website: http://hortcrsp.ucdavis.edu (includes project videos, reports, factsheets, etc.)
Evaluation Portal (will be offline in June 2013): http://hortlabevaluation.weebly.com /

- Policies and Operating Procedures
- Request for Proposal for a Horticulture CRSP from USAID
- Grant proposal from University of California, Davis to USAID for Horticulture CRSP
- Rational for Horticulture Research
- Information Management Strategy
- Innovative Technology Strategy
- Gender Strategy
- Capacity Building Strategy
- Horticulture CRSP's vision
- Organizational Chart
- Management Entity duties and responsibilities
- AOR responsibilities
- International Advisory Board bylaws and meeting minutes
- External review procedures
- Program Council responsibilities
- Program Structure and Mode of Operations
- Process for selecting sub-awards
- Rationales for each type of project
- Procedures for Enacting Organizational Changes
- Procedure to Initiate New RFPs
- Project Reporting Requirements
- Regional Centers of Innovation Overview, Policies Manual, and Technology Toolbox
- Accounting and Financial Policies
- Travel Policies and Trip Reports
- Participant Training Policies
- Communications Policies (including Branding and Marketing)
- Event and Annual Meeting Policies
- Monitoring and Evaluation Plan
- Immediate Impact Projects - Rationale for RFP, RFP, Initial Proposals Received, Reviewers (CVs and Reviews), Full Proposals Solicited and Received, Letters to PIs, Progress Reports, Final Reports
- Exploratory Projects - Rationale for RFP, RFP, Initial Proposals Received, Reviewers (CVs and Reviews), Full Proposals Solicited and Received, Letters to PIs, Progress Reports, Final Reports
- Pilot Projects - Rationale for RFP, RFP, Initial Proposals Received, Reviewers (CVs and Reviews), Full Proposals Solicited and Received, Letters to PIs, Progress Reports

- Comprehensive Projects - Rationale for RFP, RFP, Initial Proposals Received, Reviewers (CVs and Reviews), Full Proposals Solicited and Received, Letters to PIs, Progress Reports
- Focus and Continuation Projects - Rationale for RFP, RFP, Initial Proposals Received, Reviewers (CVs and Reviews), Full Proposals Solicited and Received, Letters to PIs, Progress Reports
- Trellis Projects - Proposal to the Hort CRSP ME and USAID for Trellis, RFPs, Full Proposals Received, Call for student Proposals, Student Applications, Reviewers, Review Sheet (Criteria), Reviews, Acceptance and rejection letters, Final Report Form to organizations, Overall 2011 Final Report
- ME trip reports
- ME Meetings and Notes
- International Meetings - Annual Meetings, Agenda, List of Attendees, PowerPoints, Posters, Shared Materials, Photos, Reports, and Follow-up
- ME Retreat records
- Technology Transfer/Approach and Results
- Horticulture CRSP promotional materials
  - a Newsletters
    - i January 2013: Volume 4, Issue 1
    - ii January 2012: Volume 3, Issue 1
    - iii October 2011: Volume 2, Issue 3
    - iv August 2011: Volume 2, Issue 2
    - v February 2011: Volume 2, Issue 1
    - vi November 2010: Volume 1, Issue 3
    - vii June 2010: Volume 1, Issue 2
    - viii February 2010: Volume 1, Issue 1
  - b Annual Reports
    - i 2009-2010
    - ii 2010-2011
    - iii 2011-2012 (in part)
  - c Factsheets and brochures
    - i Brochure
    - ii Horticulture CRSP partners with top scientists
    - iii Horticulture CRSP Regional Centers of Innovation overview
    - iv Trellis Fund projects
    - v Innovative technologies for horticultural development (PDF)
    - vi Ongoing and completed projects table (PDF)
    - vii Feed the Future and Horticulture CRSP
    - viii The Role of Horticulture in Alleviating Nutritional Deficiencies in the Developing World
    - ix Postharvest Technology in the Developing World
    - x The Promise of High Value Horticulture for Poverty Reduction
    - xi Horticulture CRSP in Central America
    - xii Horticulture CRSP in East Africa
    - xiii Horticulture CRSP in Asia

Appendix 7. Publications/Presentations from Horticulture Innovation Lab PIs

Stiling, James; Li, Simon; Stroeve, Pieter; Thompson, Jim; Mjawa, Bertha; Kornbluth, Kurt; Barrett, Diane M. 2012. Performance Evaluation of an Enhanced Fruit Solar Drying Using Concentrating Panels. Energy for Sustainable Development 16: 224-230

Bates, R.; Bicksler, A.; Burnette, R.; Gill, T; Meitzner-Yoder, L.; Srigiofun, Y. 2010. Improving the Preservation and Promotion of Underutilized Crop Species in Southeast Asia. Combined Proceedings International Plant Propagators' Society.60: 151-154.

Ristaino, J.B. 2012. A Lucid Key to the Common Species of Phytophthora. 2012. Plant Disease 96:897-903.

E.O. Gogo, M. Saidi, F.M. Itulya, T. Martin, and M. Ngouajio 2012. Microclimate Modification Using Eco-Friendly Nets for High Quality Tomato Transplant Production by Small-Scale Farmers in East Africa. HorTechnology 22 (3): 292-298.

Bicksler, A.; Bates, R.; Burnett, R.; Gill, T.; Meitzner Yoder, L.; Srigiofun, Y.
2011. Methodologies for Strengthening Informal Indigenous Vegetable Seed Systems in Northern Thailand and Cambodia. Acta Horticulturae (Accepted}.

Bates, R.; Bicksler, A.; Burnette, R.; Gill, T. 2011. Designing Strategies and Systems to Identify, Preserve and Promote Underutilized Crop Species. Acta Horticulturae (Accepted).

Muleke E.M., M. Saidi, F.M. Itulya, T. Martin, and M. Ngouajio. 2012. The assessment of the use of eco-friendly nets to ensure sustainable cabbage seedling production in Africa. Agronomy (Manuscript submitted).

Ngouajio, M. T. Martin, L. A. Wasilwa, F. A. Komlan, M. Saidi, E. O. Gogo, S. Simon, S. Subramanian, M. Kasina, F. Omari, A. Adegbidi, L. Parrot, D. Ahouangassi, P. Guillet 2012. Improved Small-scale Vegetable Production and Productivity in Africa with the Use of Agricultural Nets. Presentation at ASHS Annual Meeting July 2012 Orlando Fla.

F. Vidogbéna, J. Akodogbo, A. Adégbidi, R. Tossou, F.Assogba-Komlan, M. Ngouajio, T. Martin, S. Simon, L. Parrot. 2012. Farmer’s perceptions of Eco-friendly nets adapted to vegetable production in Benin. ISHS European Horticulture Symposium. Angers France 1-5 July 2012.

Appendix 8.
Partners and Collaborators in Horticulture Innovation Lab projects during initial five year phase

Project	Role	Name	Country	Email
Seed Systems – Improving Seed Quality for Smallholders - Comprehensive Projects	PI	Kent Bradford	USA	kjbradford@ucdavis.edu
	Partner	Peetambar Dahal	USA	pdahal@ucdavis.edu
	Partner	Luke Colavito	Nepal	lcolavito@idenepal.org
	Partner	Jwala Bajracharya	Nepal	seedtech@wlink.com.np
	Partner	Indra Raj Pandey	Nepal	indra.pandey@ceapred.org.np
	Partner	Keshavulu Kunusoth	India	keshava_72@yahoo.com
	Partner	Johan Van Asbrouck	Thailand	johan.rhino@gmail.com
	Partner	Ganesh Shivakoti	Thailand	ganeshshivakoti@yahoo.com
	Partner	Roger Day	Kenya	r.day@cabi.org
Semillas de Esperanza: Vegetable Seeds for Sustainable Agriculture - Pilot Projects	PI	James Nienhuis	USA	nienhuis@wisc.edu
	Partner	Suzanne Dove	USA	sdove@bus.wisc.edu
	Partner	Peter Hanson	Taiwan	peter.hanson@worldveg.org
	Partner	Paul Gniffke	Taiwan	paul.gniffke@worldveg.org
	Partner	Doris Hernandez	El Salvador	dora.hernandez@ca.care.org
	Partner	Claudia Eugenia Flores de Leon	Guatemala	claudia.flores@ca.care.org
	Partner	Edgar Ascensio	El Salvador	edgar.ascencio@ca.care.org
	Partner	Martha Moraga	Nicaragua	martha.moraga@una.edu.ni
	Partner	Maria de los Angeles	Nicaragua	unknown
	Partner	Francisco Salmeron	Nicaragua	fsalmeron99@yahoo.com
	Partner	Tomas Laguna	Nicaragua	unknown
	Partner	Donald Breazeale	Honduras	breazealedonald@gmail.com
	Partner	Javier Diaz	Honduras	fjdiaz15@gmail.com
New Technology for Postharvest Drying and Storage of Horticultural Seeds - Immediate Impact Project	PI	Kent Bradford	USA	above
	Partner	Peetambar Dahal	USA	above
	Partner	Jwala Bajracharya	Nepal	above
	Partner	Bhartendu Mishra	Nepal	ednarc@ntc.net.np
	Partner	Keshavulu Kunusoth	India	above

	Partner	Johan Van Asbrouck	Thailand	above
Sustainable Production and Marketing of Vegetables in Central America - Immediate Impact Project	PI	James Nienhuis	USA	above
	Partner	Peter Hanson	Taiwan	above
	Partner	Paul Gniffke	Taiwan	above
	Partner	Doris Hernandez	El Salvador	above
	Partner	Donald Breazeale	Honduras	above
	Partner	Martha Moraga	Nicaragua	above
Strengthening Indigenous Informal Seed Systems in Southeast Asia - Exploratory Project	PI	Ricky Bates	USA	rmb30@psu.edu
	Partner	Thomas Gill	USA	tbg12@psu.edu
	Partner	Rick Burnette	Thailand	echoasia@echonet.org
	Partner	Laura Meitzner Yoder	Thailand	lyoder@isdsi.org
	Partner	Abram Bicksler	Thailand	abram.bicksler@gmail.com
	Partner	Yongyooth Srigiofun	Thailand	yysgf@mju.ac.th
Low cost pest exclusion and microclimate modification technologies for small scale vegetable growers in East and West Africa - Pilot Project	PI	Mathieu Ngouajio	USA	ngouajio@msu.edu
	Partner	Thibaud Martin	France	thibaud.martin@cirad.fr
	Partner	Francoise Komlan	Benin	fassogbakomlan@gmail.com
	Partner	Lusike Wasilwa	Kenya	lwasilwa@gmail.com
	Partner	Anselme Adegbidi	Benin	anselmeadegbidi@hotmail.com
	Partner	Damien Ahouangassi	Benin	apretect@yahoo.fr
	Partner	Serge Simon	Benin	serge.simon@cirad.fr
	Partner	Mwanarusi Saidi	Kenya	mwanarusi@yahoo.com
	Partner	Pierre Guillet	Tanzania	pierre@vectorhealth.com
	Partner	Laurent Parrot	France	laurent.parrot@cirad.fr
Deployment of Rapid Diagnostic Tools for Phytophthora on Horticultural Crops in Central America - Immediate Impact Project	PI	Jean Ristaino	USA	Jean_Ristaino@ncsu.edu
	Partner	Kelly Ivors	USA	kelly_ivors@ncsu.edu
	Partner	Carrie Harmon	USA	clharmon@ufl.edu
	Partner	Peter Bonants	Netherlands	peter.bonants@wur.nl
	Partner	Monica Blanco Menenses	Costa Rica	monicablmn@gmail.com
	Partner	Jose Melgar	Honduras	jmelgar@fhia.org.hn
Improving Fruit Postharvest Quality through	PI	Bielinski Santos	USA	bmsantos@ufl.edu

Best Management Practices for Perishable Vegetable Production in Protective Structures in Nicaragua, Haiti, Honduras, Dominican Republic and Costa Rica - Immediate Impact Project	Partner	Teresa Salame	USA	tsalame@ufl.edu
	Partner	Maricruz Ramirez-Sanchez	USA	unknown
	Partner	Craig Stanley	USA	unknown
	Partner	Jack Rechcigl	USA	unknown
	Partner	Henner Obregon-Olivas	Nicaragua	hennerobregon@gmail.com
	Partner	Jessie Inestroza	Honduras	jeynestroza@yahoo.com
	Partner	Maria Cuevas	Dominican Republic	mcuevas@idiaf.org.do
	Partner	Marco Saenz	Costa Rica	marco.saenz@ucr.ac.cr
	Partner	Jean-Robert Estime	Haiti	jestime@winner.ht
Indigenous African Leafy Vegetables (ALV) for Enhancing Livelihood Security of Smallholder Farmers in Kenya - Immediate Impact Project	PI	Stephen Weller	USA	weller@purdue.edu
	Partner	Dharma Pitchay	USA	dpitchay@tnstate.edu
	Partner	Mathieu Ngouajio	USA	above
	Partner	Pamela Obura	Kenya	pobura@purdue.edu
	Partner	Grace Cheserek	Kenya	gcheserek@yahoo.com
	Partner	Elizabeth Omami	Kenya	elizabethomami@yahoo.com
	Partner	Julius Ochuodho	Kenya	juliusochuodho@yahoo.com
	Partner	Christine Ndinya	Kenya	christinendinya@yahoo.com
	Partner	Chris Ojiewo	Tanzania	Chris has left his job
Agricultural Technology Transfer in Kenya; A New Approach to Training and Engagement - Exploratory	PI	Steve Fennimore	USA	safennimore@ucdavis.edu
	Partner	Jeff Mitchell	USA	jpmitchell@ucanr.edu
	Partner	Peter Mutua	Kenya	shekinamf@gmail.com
Toward increasing Smallholder-Vegetable Farmer Utilization of Grafting and Low and High Tunnel Microclimate Management Tools - Exploratory	PI	Matthew Kleinhenz	USA	kleinhenz.1@osu.edu
	Partner	J. Mark Erbaugh	USA	erbaugh.1@osu.edu
	Partner	Sally Miller	USA	miller.769@osu.edu
	Partner	Monicah Waiganjo	Kenya	monicahwaiganjo@yahoo.com
	Partner	Peter Kanyuiro	Kenya	ngigi_peter@yahoo.com
	Partner	Jeremiah Njuguna	Kenya	jeremiah.njuguna@yahoo.com
Cell Phone Enabled Personalized Agro-Advisory Services for Horticultural Crops in South Asia - Exploratory	PI	Mywish Maredia	USA	maredia@msu.edu
	Partner	Sangita Ladha	India	ihitc.director@gmail.com
	Partner	Karim Mardia	USA	kmaredia@msu.edu
	Partner	Cholani Weebadde	USA	weebadde@msu.edu

	Partner	Nanda Joshi	USA	joshin@msu.edu
	Partner	Rajesh Urkude	India	unknown
Market Oriented Sustainable Peri-Urban and Urban Garden Cropping System: A Model for Women Farmers in Thailand, Cambodia and Vietnam - Exploratory Project	PI	Dharma Pitchay	USA	above
	Partner	Surendra Singh	USA	ssingh@tnstate.edu
	Partner	Sammy Comer	USA	scomer@tnstate.edu
	Partner	Juan Carlos Diaz-Perez	USA	jcdiaz@uga.edu
	Partner	Robert Holmer	Thailand	robert.holmer@worldveg.org
	Partner	Yingyong Paisooksantivatana	Thailand	yp2624@yahoo.com
	Partner	Pariyanuj Chulaka	Thailand	agrpnc@ku.ac.th
	Partner	Prabhat Kumar	Thailand	pkipm@ait.asia
Geographic Information Accessibility for Improving Horticultural-Based Income Generation in the Mzimba District of Malawi - Exploratory	PI	Darcy Boellstorff	USA	dboellstorff@bridgew.edu
	Partner	Gibson Nkanaunena	Malawi	gnkanaunena@wr.org
	Partner	Moses Jemitale	Malawi	mjemitale@wr.org
	Partner	Hudson Kaunda	Malawi	hkaunda@wr.org
Extension of Appropriate Postharvest Technology in Sub-Saharan Africa: A Postharvest Training and Services Center - Pilot Project	PI	Diane Barrett	USA	dmbarrett@ucdavis.edu
	Partner	Lisa Kitinoja	USA	kitinoja@hotmail.com
	Partner	Rob Shewfelt	USA	shewfelt@uga.edu
	Partner	Victor Afari-Sefa	Tanzania	victor.afari-sefa@worldveg.org
Sustainable Development of Horticultural Crops in Zambia by Introducing Postharvest Technologies and Practices for Food Security, Income Generation and in Support of the Tourism Industry - Continuation	PI	James Simon	USA	jesimon123@gmail.com
	Partner	Rodolfo Juliani	USA	hjuliani@rci.rutgers.edu
	Partner	Petrus Langenhoven	South Africa	petrusl@sun.ac.za
	Partner	Newton Phiri	Zambia	pnewton73@yahoo.com
	Partner	Elke Crouch	South Africa	elke@sun.ac.za
	Partner	Bill Sciarappa	USA	sciarappa@aesop.rutgers.edu
	Partner	Ramu Govindasamy	USA	govindasamy@aesop.rutgers.edu
	Partner	Albert Ayeni	USA	ayeni@aesop.rutgers.edu
	Partner	Rick VanVranken	USA	vanvranken@rci.rutgers.edu
	Partner	Stephen Weller	USA	above
	Partner	Richard Tracy	USA	rtracy@gcca.org
	Partner	Lisa Kitinoja	USA	above
Concentrated Solar Drying of Mango and Tomato - Immediate Impact Project	PI	Diane Barrett	USA	above
	Partner	Pieter Stroeve	USA	pstroeve@ucdavis.edu

	Partner	Jim Thompson	USA	jfthompson@ucdavis.edu
	Partner	Kurt Kornbluth	USA	kkorn@ucdavis.edu
	Partner	Bertha Mjawa	Tanzania	bmjawa@yahoo.com
Biological-Based Postharvest Quality Maintenance and Disease Control for Mango and Papaya - Exploratory Project	PI	Robert Paull	USA	paull@hawaii.edu
	Partner	Nancy Chen	USA	jungc@hawaii.edu
	Partner	Shanthi Wilson Wijeratnam	Sri Lanka	shanthi@iti.lk
Coolrooms and Cool Transport for Small-Scale Farmers - Immediate Impact	PI	Michael Reid	USA	msreid@ucdavis.edu
	PI	Jim Thompson	USA	above
	Partner	Cecilia Chi-Ham	USA	clchiham@ucdavis.edu
	Partner	Neeru Dubey	India	needub@gmail.com
	Partner	Royce Gloria Androa	Uganda	androarga@gmail.com
	Partner	Dinie Espinal-Rueda	Honduras	drueda@zamorano.edu
	Partner	Ron Khosla	USA	ron@storeitcold.com
Integrated Postharvest Extension Program for Cambodia and Vietnam - Exploratory	PI	Robert Paull	USA	above
	Partner	Nancy Chen	USA	above
	Partner	Nguyen Quoc Vong	Vietnam	nqvong@hua.edu.vn
	Partner	Men Sarom	Cambodia	msarom@gmail.com
Delivering Vegetable Safety Education through Established Social Networks in Latin America - Continuation	PI	Jeffrey LeJeune	USA	lejeune.3@osu.edu
	Partner	Alfredo Rueda	Honduras	Alfredo has left his job
	Partner	Julio Lopez	Nicaragua	unknown
	Partner	Eduardo Pretzanzin	Guatemala	edu.pretza@gmail.com
	Partner	Yordana Valenzuela	Honduras	unknown
Enhancing Trade in Horticultural Crops Through Food Safety and Phytosanitary Measures - IIP	PI	Sally Miller	USA	above
	Partner	Jeffrey LeJeune	USA	above
	Partner	J. Mark Erbaugh	USA	above
	Partner	Kenneth Shenge	Nigeria	kcshenge@gmail.com
A Regional Approach to Food Safety for Fruits and Vegetables in Bangladesh - Exploratory	PI	Ronnie Coffman	USA	wrc2@cornell.edu
	Partner	K. Vijayaraghavan	India	vijay@sathguru.com
	Partner	K.V. Raman	USA	kvr1@cornell.edu
	Partner	Anusuya Rangarajan	USA	unknown
	Partner	Glenn Young	USA	gmyoung@ucdavis.edu
	Partner	Shirazul Islam	Bangladesh	unknown

Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers – IIP	PI	Stephen Weller	USA	above
	Partner	Maria Marshall	USA	mimarsha@purdue.edu
	Partner	James Simon	USA	above
	Partner	Pamela Obura	Kenya	above
	Partner	Chris Ojiewo	Tanzania	Chris has left his job
	Partner	Petrus Langenhoven	South Africa	above
Safe Vegetable Production in Cambodia and Vietnam: Developing the HARE-Network to Enhance Farmer Income, Health, and the Local Environment - Pilot	PI	Cary Trexler	USA	cjtrexler@ucdavis.edu
	Partner	Johan Six	USA	Johan has left his job
	Partner	Glenn Young	USA	above
	Partner	Mark Van Horn	USA	mxvanhorn@ucdavis.edu
	Partner	David Miller	USA	gdmiller@ucdavis.edu
	Partner	Nguyen Quoc Vong	Vietnam	above
	Partner	Nguyen Thi Bich Thuy	Vietnam	unknown
	Partner	Pham Thi Huong	Vietnam	ptong@hau1.edu.vn
	Partner	Pham Bao Duong	Vietnam	pbduong@hua.edu.vn
	Partner	Pham Van Hung	Vietnam	ntnthuy@hua.edu.vn
	Partner	Thong Kong	Vietnam	kthong73@yahoo.com
	Partner	Borarin Bunton	Cambodia	bborarin@rua.edu.kh
	Partner	Asikin Yoeu	Cambodia	asikinyoeu@yahoo.com
	Partner	Lyda Hok	Cambodia	hoklyda@rua.edu.kh
	Partner	Lor Lytour	Cambodia	lor_lytour@yahoo.com
	Partner	Lam Thanh Hien	Vietnam	lamthanh_hien@hcm.vnn.vn
	Partner	Phan Thi Giac Tam	Vietnam	ptgtam@hcm.fpt.vn
	Partner	Thai Anh Hoa	Vietnam	tahoa@hcm.vnn.vn
	Partner	Pham Thi Minh Tam	Vietnam	phamminhtam@gmail.com
Sustainable Production of Specialty Horticultural Crops in Ghana for Income Generation and Increased Export Value - IIP	PI	James Simon	USA	above
	Partner	Dan Acquaye	Ghana	dacquaye@gmail.com
	Partner	Juliana Asante-Dartey	Ghana	jadartey@hotmail.com
	Partner	Charles Quansah	Ghana	cquansah2002@yahoo.co.uk
	Partner	Rodolfo Juliani	USA	above
	Partner	Ramu Govindasamy	USA	above

	Partner	Joe-Ann McCoy	USA	jmccoy@ncarboretum.org
Sustainable Development of Horticultural Crops in Zambia for Food Security, Income Generation and in Support of the Tourism Industry - IIP	PI	James Simon	USA	above
	Partner	Bismarck Diawuo	Zambia	bhadbad@yahoo.com
	Partner	Elton Jefthas	South Africa	ejefthas@sun.ac.za
	Partner	Petrus Langenhoven	South Africa	above
	Partner	Rodolfo Juliani	USA	above
	Partner	Ramu Govindasamy	USA	above
Evaluating the Support Structure for Production and Marketing of Tomatoes and Paprika Among Smallholders in Zimbabwe - Exploratory	PI	Hans Christian Wien	USA	hcw2@cornell.edu
	Partner	Edward Mabaya	USA	em37@cornell.edu
	Partner	Beth Medvecky	USA	bam44@cornell.edu
	Partner	Ralph Christy	USA	rdc6@cornell.edu
	Partner	Themos Ntasis	Zimbabwe	tntasis@ird-dc.org
	Partner	Isatou Jack	Zimbabwe	ijack@ird-dc.org
Sustainable Technology for Orange and Purple Sweetpotato (STOPS) in Ghana - Continuation	PI	Eunice Bonsi	USA	ebonsi@mytu.tuskegee.edu
	Partner	Conrad Bonsi	USA	cobonsi@mytu.tuskegee.edu
	Partner	Prosper Doamekpor	USA	doamekpor@mytu.tuskegee.edu
	Partner	Desmond Mortley	USA	mortleyd@mytu.tuskegee.edu
	Partner	Robert Zabawa	USA	zabawar@mytu.tuskegee.edu
	Partner	Thomas Gill	USA	above
	Partner	Leland Glenna	USA	llg13@psu.edu
	Partner	Janelle Larson	USA	jbl6@psu.edu
	Partner	Sjoerd Duiker	USA	swd10@psu.edu
	Partner	Kwami Offei	Ghana	agricdean@ug.edu.gh
	Partner	Wisdom Plahar	Ghana	waplahar@fri.csir.org.gh
	Partner	Hans Adu-Dapaah	Ghana	cridirector@cropsresearch.org
	Partner	Stephen Nutsugah	Ghana	sknutsugah@hotmail.com
	Partner	Fafali Azaglo	Ghana	selasiefarms@yahoo.co.uk
	Partner	Joseph Apedo	Ghana	pledi@yahoo.com
	Partner	Hawa Musah	Ghana	hawamusah2@yahoo.com
	Partner	Nana Ayim Poakwah	Ghana	nanayim@yahoo.com
Concentrated Nutritional and Economic Enhancement of Ghanaian Diets Using	PI	Eunice Bonsi	USA	above
	Partner	Conrad Bonsi	USA	above

Orange-Fleshed Sweetpotato Products - IIP		Robert Zabawa	USA	above
		Prosper Doamekpor	USA	above
		Ellene Kebede	USA	kebede@mytu.tuskegee.edu
		Curtis Jolly	USA	cjolly@auburn.edu
		Kwami Offei	Ghana	above
		Felix K. Forfoe	Ghana	fkforfoe@yahoo.com
		Wisdom Plahar	Ghana	above
		Marian Dorcas Quain	Ghana	md.quain@cropsresearch.org
		Fafali Azaglo	Ghana	above
		Joseph Apedo	Ghana	above
Increasing the Capacity of Smallholder Farmers to Produce and Market Vegetable Crops in Uganda and Democratic Republic of Congo - Pilot	PI	Kate Scow	USA	kmscow@ucdavis.edu
	Partner	Johan Six	USA	Johan has left his job
		Mark Van Horn	USA	above
		Heidi Ballard	USA	hballard@ucdavis.edu
		Stephen Boucher	USA	boucher@ucdavis.edu
		Edith Naggenda	Uganda	nagenda@yahoo.com
		Ignitius Bwoogi	Uganda	binkokoster@gmail.com
		Michael Masanza	Uganda	mmasanza@ucu.ac.ug
		Beatrice Akello	Uganda	Beatrice has left her job
		Peter Lusembo	Uganda	mknardc@africaonline.co.ug
		Harriet Nsubuga Mpanga	Uganda	harriet.nsubuga@gmail.com
		Prossy Isubikalu	Uganda	ikalu@agric.mak.ac.ug
		Dennis Yiga	Uganda	dyiga@yahoo.com
		Karel Van Laer	DRC	charlesvanlaer@yahoo.fr
Innovative Energy Solutions in Horticulture – Focus	PI	Kurt Kornbluth	USA	above
	PI	Jim Thompson	USA	above
	PI	Michael Reid	USA	above
Building an Ornamental Plant Industry in Honduras - IIP	PI	Alan Bennett	USA	abbennett@ucdavis.edu
	Partner	Cecilia Chi-Ham	USA	above
	Partner	Michael Dobres	USA	mdobres@novaflora.edu
	Partner	Dinie Espinal-Rueda	Honduras	above
	Partner	David Flemmin	USA	david@coenesa.com

Improving Market Access for Emerging South African Rooibos Farmers - IIP	PI	Laura Raynolds	USA	laura.raynolds@colostate.edu
	Partner	Andries du Toit	South Africa	adutoit@uwc.ac.za
	Partner	Douglas Murray	USA	douglas.murray@colostate.edu
	Partner	Jennifer Keahey	USA	jennifer.keahey@colostate.edu
	Partner	Sandra Kruger	South Africa	kruger.sandra@gmail.com
Promoting Fruit and Vegetable Production to Improve Nutrition in Nkokonjeru, Uganda – IIP	PI	Kate Scow	USA	above
	Partner	Edith Naggenda	Uganda	above
	Partner	Ignitius Bwoogi	Uganda	above
	Partner	Charles Jjemba	Uganda	jchlwanga@yahoo.co.uk
	Partner	Michael Masanza	Uganda	above
	Partner	Peter Lusembo	Uganda	above
Improving extension methods for horticultural outreach among small-stakeholder farmers in Latin American countries - Exploratory	PI	Jeffrey LeJeune	USA	above
	Partner	Juan Antonio Canumir	Chile	jcanumir@udec.cl
	Partner	Rudi Radrigan	Chile	rradriga@udec.cl
	Partner	Maria Gonzalez	Chile	mariaegonzalez@udec.cl
	Partner	Patricia Contreras	Chile	pattymarcelacu@gmail.com
	Partner	Sandra Kruger	South Africa	above
	Partner	Andres Cases Diaz	Peru	cda@lamolina.edu.pe
	Partner	Eduardo Mendoza Garcia	Bolivia	edudoza@yahoo.com
	Partner	Mario Montenegro-Jimenez	Ecuador	mariomonte2004@hotmail.com
	Partner	Eduardo Pretzanzin	Guatemala	above
	Partner	Gerardo Agresta	Uraguay	agresta@ricaldoni.org.uy

Appendix 9. Students Trained with Partial or Full Funding from the Horticulture CRSP

Name of Student	Native Country	Institution Trained At	Degree Attained/ Working On	Partial of Full Funding Provided by HortCRSP	Year Expected to Graduate	Project	Project Dates	Sex	Year Started
Blake Ringelsen	USA	University of California, Davis	M.S.	Partial	2011	Barrett IIP	2010-11	Male	
James Stiling	USA	University of California, Davis	M.S.	Partial	2013	Barrett IIP	2010-11	Male	
Simon Li	USA	University of California, Davis	B.S.	Partial	2011	Barrett IIP	2010-11	Male	
Zaine Venter	South Africa	Bridgewater State University	B.S.	Partial	2011	Boellstorff EP	2010-11		
Joel Chongela	Tanzania	ANGRAU, Hyderabad	Ph.D.	Outside Funding	2013	Bradford CP	2011-14	Male	
Krishna Timsina	Nepal	Asian Institute of Technology	Ph.D.	Partial	2014	Bradford CP	2011-14	Male	
Mathura Yadav	Nepal	ANGRAU, Hyderabad	M.S.	Outside Funding	2011	Bradford CP	2011-14	Male	
Peter Jackson	Tanzania	ANGRAU, Hyderabad	M.S.	Outside Funding	2012	Bradford CP	2011-14	Male	
Dylan Owen	USA	University of California, Davis	B.S. Computer Science	Partial	2014	ME	2009-2014	Male	
Elana Peach-Fine	USA	University of California, Davis	M.S. IAD	Full	2013	ME	2009-2014	Female	
Kelsey Barale	USA	University of California, Davis	M.S. IAD	Partial	2013	ME	2009-14	Female	
Peter Shapland	USA	University of California, Davis	M.S. IAD	Full	2011	ME	2009-2014	Male	
Gayeon Won	South Korea	The Ohio State University	Ph.D.	Partial	2012	Miller IIP	2010-11	Male	
Carlos Ramirez	Costa Rica	Instituto Tecnologico de Costa Rica	Ph.D.	Outside Funding	2011	Neinhuis PP	2010-13	Male	
Xiomara Mata	Costa Rica	Instituto Tecnologico de Costa Rica	Ph.D.	Outside Funding	2013	Neinhuis PP	2010-2013	Female	
Abel Too	Kenya	Moi University	M.S. Plant Pathology	Partial	2014	Ngouajio PP	2010-13	Male	2012
Carolyn Achieng'a	Kenya	Kenyatta University	M.S.	Partial	2012	Ngouajio PP	2010-2013	Female	
Catherine Gacheri	Kenya	Kenyatta University	M.S.	Partial	2012	Ngouajio PP	2010-2013	Female	
Elisha Otieno Gogo	Kenya	Egerton University	M.S.	Partial	2013	Ngouajio PP	2010-2013	Female	
Everlyne M'mbone Muleke	Kenya	Egerton University	M.S.	Partial	2013	Ngouajio PP	2010-2013	Female	
Faustin Vidogbéna	Benin	University of Abomey-Calavi	Ph.D.	Partial	2014	Ngouajio PP	2010-2013	Male	
Gildas M. Adjovi	Benin	University of Abomey-Calavi	B.S.	Partial	2011	Ngouajio PP	2010-13	Male	
Ginette Azandeme	Benin	Montpelier University	Ph.D. Plant Pathology	Partial	2015	Ngouajio PP	2010-13	Female	2012
Hilaire Agonsè	Benin	GASA Formation (Private University)	B.S.	Partial	2012	Ngouajio PP	2010-2013		
Jane Gateri	Kenya	Egerton University	M.S. Horticulture	Partial	2013	Ngouajio PP	2010-13	Female	
Judith Kiptoo	Kenya	Moi University	M.S.	Partial	2012	Ngouajio PP	2010-2013	Female	
Lauriane Yehouenou	Benin	University of Abomey-Calavi	B.S.	Partial	2011	Ngouajio PP	2010-13	Female	
Miriam Kungu	Kenya	JKUAT	M.S. Crop Protection	Partial	2013	Ngouajio PP	2010-13	Female	2012

Name of Student	Native Country	Institution Trained At	Degree Attained/ Working On	Partial of Full Funding Provided by HortCRSP	Year Expected to Graduate	Project	Project Dates	Sex	Year Started
Patrick Muthee	Kenya	Egerton University and Auvergne University	Ph.D. Agribusiness Management	Partial	2015	Ngouajio PP	2010-13	Male	2012
Rustique J.G. Akodogbo	Benin	University of Abomey-Calavi	B.S.	Partial	2011	Ngouajio PP	2010-13	Male	
Rebecka Sakwa	Kenya	University of Nairobi	M.S. Crop Protection	Partial	2014	Ngouajio PP	2010-2013	Female	2012
Samuel Machuki	Kenya	University of Nairobi	M.S. Crop Protection	Partial	2014	Ngouajio PP	2010-2013	Male	2012
Sandrine S.S.L. Segla	Benin	University of Abomey-Calavi	B.S.	Partial	2011	Ngouajio PP	2010-13	Female	
Undergrad 1	Benin	University of Abomey-Calavi	B.S.	Partial	2014	Ngouajio PP	2010-2013	Female	
Undergrad 2	Benin	University of Abomey-Calavi	B.S.	Partial	2014	Ngouajio PP	2010-2013	Male	
Undergrad 3	Benin	University of Abomey-Calavi	B.S.	Partial	2014	Ngouajio PP	2010-2013	Male	
Victor Agohoundjè	Benin	University of Abomey-Calavi	B.S.	Partial	2012	Ngouajio PP	2010-2013	Male	
Victor Juma	Kenya	Kenyatta University	M.S.	Partial	2012	Ngouajio PP	2010-2013	Male	
Julissa Alcazar	Costa Rica	University of Wisconsin, Madison	B.S.	Partial	2010	Nienhuis IIP	2010-11	Female	
Linnzi Hodel	USA	University of Wisconsin, Madison	M.S. Horticulture	Partial	2011	Nienhuis IIP	2010-11	Female	
Paulina Quesdada	Costa Rica	University of Wisconsin, Madison	B.S.	Partial	2011	Nienhuis IIP	2010-11	Female	
Raul Guerra	Nicaragua	University of Wisconsin, Madison	M.S. Plant Breeding	Full	2013	Nienhuis PP	2010-13	Male	
Mai Vu Thi	Vietnam	Kasetsart University	M.S. Horticulture	Outside Funding		Pitchay EP	2010-2011	Female	
Ong Socheath	Cambodia	Royal Agriculture University	M.S. Agronomy	Partial		Pitchay EP	2010-2011	Female	
Tan	Thailand	Kasetsart University	M.S. Horticulture	Partial		Pitchay EP	2010-2011	Female	
Jennifer Keahey	USA	Colorado State Univeristy	Ph.D.	Full	2012	Raynolds IIP	2010-11	Female	
Ariana Rundquist	USA	University of California, Davis	M.S.	Partial	2012	Reid IIP	2010-11	Female	
Barbara Wanyanya	Uganda	Uganda Christian University	B.S.	Partial	2013	Scow PP	2010-13	Female	
Daniel Ntale	Uganda	Uganda Christian University	B.Sc.	Outside Funding	2013	Scow PP	2010-13	Male	
Jones Muhindo	Uganda	Uganda Christian University	B.Sc.	Partial	2012	Scow PP	2010-13	Female	
Lauren Pincus	USA	University of California, Davis	Ph.D.	Full	2014	Scow PP	2010-13	Female	
Leah Nandudu	Uganda	Uganda Christian University	B.S.	Partial	2014	Scow PP	2010-13	Female	
Nassib Mugwanya	Uganda	Makerere University	M.S.	Full	2012	Scow PP	2010-13	Male	
Ruth Buteme	Uganda	Uganda Christian University	B.S.	Partial	2014	Scow PP	2010-13	Female	
Sebastian Walugembe	Uganda	Uganda Christian University	B.S.	Partial	2012	Scow PP	2010-13	Male	

Name of Student	Native Country	Institution Trained At	Degree Attained/ Working On	Partial of Full Funding Provided by HortCRSP	Year Expected to Graduate	Project	Project Dates	Sex	Year Started
Shakira Nakasagga	Uganda	Uganda Christian University	B.S.	Partial	2013	Scow PP	2010-13	Female	
Stellah Kukunda	Uganda	Uganda Christian University	B.Sc.	Partial	2012	Scow PP	2010-13	Female	
William Sekamate	Uganda	Makerere University	M.S.	Partial	2012	Scow PP	2010-13	Male	
Allison Ferry	USA	University of California, Davis	Ph.D. Plant Pathology	$2000 Trellis Fellowship	2014	Trellis	2010-11	Female	
Eduardo Gutierrez-Rodriguez	Costa Rica	University of California, Davis	Ph.D. Horticulture and Agronomy	$2000 Trellis Fellowship	2012	Trellis	2010-11	Male	
Gina Garland	USA	University of California, Davis	M.S. Horticulture	$2000 Trellis Fellowship	2011	Trellis	2010-11	Female	
Jenna Rodriguez	USA	University of California, Davis	M.S. Hydrological Sciences	$2000 Trellis Fellowship	2013	Trellis	2010-11	Female	
Juliet Braslow	USA	University of California, Davis	M.S. IAD	$2000 Trellis Fellowship	2012	Trellis	2010-11	Female	
Kate Fuller	USA	University of California, Davis	Ph.D. Agricultural Economics	$2000 Trellis Fellowship	2014	Trellis	2010-11	Female	
Larisa Jacobson	USA	University of California, Davis	M.S. IAD	$2000 Trellis Fellowship	2011	Trellis	2010-11	Female	
Mark Lundy	USA	University of California, Davis	Ph.D. Horticulture and Agronomy	$2000 Trellis Fellowship	2013	Trellis	2010-11	Male	
Michael Wolff	USA	University of California, Davis	Ph.D. Soil Science	$2000 Trellis Fellowship	2013	Trellis	2010-11	Male	
Cao Thi Nhan	Vietnam	Nong Lam University	B.S.	Partial	2011	Trexler PP	2010-13	Female	
Hoang Thi Minh Thuy	Vietnam	Nong Lam University	B.S.	Partial	2011	Trexler PP	2010-13	Female	
Huynh Thi Nhu Quy	Vietnam	Nong Lam University	M.S.	Partial	2012	Trexler PP	2010-13	Female	
Kham Phang	Laos	Nong Lam University	M.S.	Partial	2012	Trexler PP	2010-13	Male	
Le Minh Nhut	Vietnam	University of Agriculture and Forestry, Vietnam	B.S.	Partial	2012	Trexler PP	2010-13	Male	
Le The Bao	Vietnam	Nong Lam University	B.S.	Partial	2012	Trexler PP	2010-13	Male	
Lưu Văn Huy	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Male	
Ly Tuong Vy	Vietnam	Nong Lam University	B.S.	Partial	2012	Trexler PP	2010-13	Female	
Mai Thanh Dai	Vietnam	Nong Lam University	B.S.	Partial	2012	Trexler PP	2010-13	Male	
Mai Thi My Duyen	Vietnam	Nong Lam University	B.S.	Partial	2011	Trexler PP	2010-13	Female	

Name of Student	Native Country	Institution Trained At	Degree Attained/ Working On	Partial of Full Funding Provided by HortCRSP	Year Expected to Graduate	Project	Project Dates	Sex	Year Started
Mr Đặng Xuân Phi	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Male	
Mr Đỗ Trường Lâm	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Male	
Mr Nguyễn Anh Đức	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Male	
Mr Phạm Tiến Duật	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Male	
Ms Nguyen Thi Lý	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Female	
Ms Nguyễn Thu Hương	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Female	
Ms Phạm thị Hương Giang	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Female	
Ms Phạm Thị Xuân	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Female	
Ms Trần Như Ngọc	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Female	
Ms Vũ Thị Duyên	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Female	
Ms Vũ Thị Mai Liên	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Female	
Nguyen Pham Hong Lan	Vietnam	Nong Lam University	B.S.	Partial	2011	Trexler PP	2010-13	Female	
Nguyễn Trọng Thăng	Vietnam	Hanoi University of Agriculture	B.S.	Full	2014	Trexler PP	2010-13	Male	
Nguyen Van Nam	Vietnam	Nong Lam University	B.S.	Partial	2011	Trexler PP	2010-13	Male	
Pham Duy	Vietnam	Nong Lam University	B.S.	Partial	2011	Trexler PP	2010-13	Male	
Pham Luong Thien	Vietnam	Nong Lam University	B.S.	Partial	2011	Trexler PP	2010-13	Male	
Pham Thi Tuyet Mai	Vietnam	Nong Lam University	M.S.	Partial	2013	Trexler PP	2010-13	Female	
Sara Ashley Sparks	USA	University of Georgia	M.S.	Partial	2013	Barrett PP	2010-13	Female	
Carrie Teiken	USA	University of California, Davis	M.S.	Partial	2014	Trellis	2012-13	Female	
Bob Johnson	USA	University of California, Davis	M.S.	Partial	2013	Trellis	2012-14	Male	
Whitney Brim-deForest	USA	University of California, Davis	PhD	Partial	2014	Trellis	2012-15	Female	
AJ Campbell	USA	University of California, Davis	PhD	Partial	2015	Trellis	2012-16	Female	
Graham Savio	USA	University of California, Davis	M.S.	Partial	2014	Trellis	2012-17	Male	
Ephrem Rukundo	Rwanda	University of California, Davis	PhD	Partial	2015	Trellis	2012-18	Male	
Sarah Sahlaney	USA	University of California, Davis	M.S.	Partial	2014	Trellis	2012-19	Female	
Rachel Suits	USA	North Carolina State University	M.S.	Partial	2014	Trellis	2012-20	Female	
Arun Jani	USA	North Carolina State University	M.S.	Partial	2014	Trellis	2012-21	Male	
Amanda McWhirt	USA	North Carolina State University	PhD	Partial	2016	Trellis	2012-22	Female	
Angel Cruz	USA	North Carolina State University	M.S.	Partial	2014	Trellis	2012-23	Female	
Bryan Sobel	USA	Cornell University	M.S.	Partial	2013	Trellis	2012-24	Male	
Brian Flanagan	USA	Cornell University	M.S.	Partial	2014	Trellis	2012-25	Male	
Gabe Sachter	USA	University of Hawaii at Manoa	M.S.	Partial	2014	Trellis	2012-26	Male	

Name of Student	Native Country	Institution Trained At	Degree Attained/ Working On	Partial of Full Funding Provided by HortCRSP	Year Expected to Graduate	Project	Project Dates	Sex	Year Started
Erin McGuire	USA	University of California, Davis	M.S.	Partial	2014	ME	2012-	Female	
Azia Hasan	USA	University of California, Davis	B.A. Communications	Partial	2014	ME	2012-2014	Female	

Appendix 10. Outstanding Extension Publication Award (Website) from the American Society for Horticultural Science 2010.


The American Society for Horticultural Science

Outstanding Extension Publication Award

Horticulture Collaborative Research Support Program (CRSP)

http://hortcrsp.ucdavis.edu/

Ronald E. Voss

2010 Outstanding Website Award

Presented at the ASHS Annual Conference, August 2–5, 2010, Palm Desert, California

ASHS Extension Division Vice President

American Society for Horticultural Science Founded 1903

Appendix 11. Information Management Outputs

Some Project Outputs in different formats

Seed systems and germplasm

- Fact sheets + video: Introducing new seed storage technologies: India, Nepal, Thailand
  Kent Bradford of UC Davis, led "New Technology for Postharvest Drying and Storage of Horticultural Seeds" (~$150,000).
  Deliverables: Posters, Powerpoint, Informational Flyers, Publications and Research, FAQs

- Video: Evaluating local tomato and chili varieties for disease resistance: El Salvador, Honduras, Nicaragua
  James Neinhuis of University of Wisconsin-Madison led "Sustainable Production and Marketing of Vegetables in Central America" (~$150,000)
- Fact sheets + video: Strengthening indigenous seed systems: Bangladesh, Cambodia, Laos, Thailand, Vietnam
  Rick Bates at Penn State led "Strengthening Indigenous Informal Seed Systems in Southeast Asia" (~$75,000)

Sustainable production of horticultural crops

- Fact sheet: Demonstrating nets and floating row covers: Benin, Kenya
  Mathieu Ngouajio of Michigan State University leads "Developing Low-Cost Pest Exclusion and Microclimate Modification Technologies for Small-Scale Vegetable Growers" (~$500,000)
- Video + Manual: Training plant diagnosticians: Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Mexico, Panama
  Jean Ristaino of North Carolina State University led "Deployment of Rapid Diagnostic Tools for Phytophthora on Horticultural Crops in Central America" (~$150,000)
- Video + poster: Improving bell pepper production in passively ventilated structures: Costa Rica, Dominican Republic, Haiti, Honduras, Nicaragua
  Bielinski Santos of University of Florida led "Improving Fruit Postharvest Quality through Best Management Practices for Perishable Vegetable Production in Protective Structures" (~$150,000)
- Video + poster: Increasing production of indigenous African leafy vegetables: Kenya, Tanzania
  Stephen Weller of Purdue University led "Indigenous African Leafy Vegetables (ALV) for Enhancing Livelihood Security of Smallholder Farmers in Kenya" (~$150,000)
- Video + posters: Testing a gender-tailored extension model: Kenya
  Steve Fennimore of University of California, Davis leads "Employing a Novel Gender-Based Extension Model to More Effectively Train and Engage Horticultural Farmers" (~$75,000)
- Video + poster: Testing cell phone-based extension services: India, Nepal, Sri Lanka
  Mywish Maredia of Michigan State University leads "Cell Phone Enabled Personalized Agro-Advisory Services for Horticultural Crops in South Asia" (~$75,000)

- Video: Establishing GIS data for horticultural projects: Malawi
Darcy Boellstorff at Bridgewater State University led "Geographic Information Accessibility for Improving Horticultural-Based Income Generation in the Mzimba District of Malawi" (~$75,000)

Postharvest practices

- Video + poster: Developing a concentrated solar dryer: Tanzania
Diane Barrett of University of California, Davis led "Concentrated Solar Drying of Mango and Tomato" (~$150,000)
- Video: Developing a postharvest alternative to fungicide: Sri Lanka
Robert Paull of University of Hawaii at Manoa led "Biological-Based Postharvest Quality Maintenance and Disease Control for Mango and Papaya" (~$150,000)
- Video + poster: Demonstrating low-cost cooling technology: Honduras, India, Uganda
Michael Reid of University of California, Davis led "Coolrooms and Cool Transport for Small-Scale Farmers" (~$150,000)
- Video: Strengthening local expertise in postharvest practices: Cambodia, Vietnam
Robert Paull of University of Hawaii at Manoa leads "Integrated Postharvest Extension Program for Cambodia and Vietnam" (~$75,000)

Food safety

- Videos: Improving tomato production through local GAPs: Nigeria
Sally Miller of The Ohio State University led "Enhancing Trade in Horticultural Crops through Food Safety and Phytosanitary Measures" (~$150,000)

Marketing

- Video (Life as a cucumber): Creating a market niche for 'food-safe' vegetables: Cambodia, Vietnam
Cary Trexler at University of California, Davis leads "Increasing Food Safety and Creating a Niche in the Market for Smallholders by Educating Them in Production, Postharvest, Food Safety, and Marketing and Branding their Produce According to Specific Food Safety Standards" (~$500,000)
- Video: Improving marketing capacity for specialty crops: Ghana
James Simon at Rutgers University led "Sustainable Production of Specialty Horticultural Crops in Ghana for Income Generation and Increased Export Value" (~$150,000)
- Video: Improving vegetable quality with local market support: Zambia
James Simon at Rutgers University led "Sustainable Development of Horticultural Crops in Zambia for Food Security, Income Generation and in Support of the Tourism Industry" (~$150,000)

Nutrition

- Video: Increasing nutrients in traditional diets with orange-fleshed sweet potatoes: Ghana
Eunice Bonsi of Tuskegee University led "Concentrated Nutritional and Economic

Enhancement of Ghanaian Traditional Diets, Using Orange-Fleshed Sweetpotato Products" (~$150,000)

Enabling environment

- Video + Facebook: Expanding the floral industry: Honduras
  Alan Bennett of University of California, Davis led "Building an Ornamental Plant Industry in Honduras" (~$150,000)
- Video: Integrating Rooibos tea farmers with fair-trade markets: South Africa
  Laura Raynolds of Colorado State University led "Improving Market Access for Emerging South African Rooibos Farmers" (~$150,000)
- Video: Strengthening farmer groups to increase fruit and vegetable production: Uganda
  Kate Scow of University of California, Davis led "Promoting Fruit and Vegetable Production to Improve Nutrition in Nkokonjeru, Uganda" (~$150,000)

Appendix 12. Information Management List of Links to Gaps, Events, Meetings and Workshops.

Information Access - Gaps, Events and Workshops

Major lessons learned Summary

Note - These activities link with those in eAfghan Ag and MEAS projects. Framework questions to ask **Link**
ICT reviews
- Extension Framework - **Link**
- ICT and Extension - MEAS, Mark et al **Link**
- G8 Consultation -MEAS, Mark et al **Report**
- eAfghan Ag "ICTs in Ag" **Link**

1. Cell Phones - Elana, Curran, Kelsey, Jappy **Link**
2. On-Line learning - Maria Paz
3. Radio - Jessica
4. Social Media (and gender) - Heather
5. Video development and use - Nick
6. Internet - interactive animation - Hussain
7. Use of the internet - Mark et al. Example site **eAfghan Ag** ; Guidelines for developing your own Knowledge Bank **Manual**

Thailand (February 2012) (Peter)

- **Survey**

Thailand (October 2012) (Mark)

- **Trade Fair survey** - Project **link** - Kent Bradford, Johan Van Asbrouck, Rhino Research, Thailand
- World Vegetable Regional course: AVRDC IVTC
- Grant Singleton, IRRI
- Survey questions
- Extension observations
- IVTC Class (12 participants from throughout Asia) **(Participant list)**

Cambodia (October 2012) (Mark)

- Survey - Project **link** - Miller, Trexler, FINTRAC, CARDI, RUA, Oxfam, Ministry,
- **Survey questions**
- **Summary outputs/lessons learned**
- Farmer village meetings and field visit with Freddy and Neda (15 farmers)

Tanzania (October 2012) (Amanda)

- Post Harvest - **Project Link** - Diane Barrett
- Course structure
- **Summary outputs**/lessons learned

Bangladesh (MEAS December 2012) (Mark)

- ICT in Extension **observations**
- Workshop with over 40 participants; subsequent farmers group meetings in 3 villages (68 participants) and meetings with regional extension offices (3 offices) and farmers field visit

- **Survey Analysis**

Uganda (May 2012) (Peter and Elana)

- Workshop - Project **link** - Kate Scow
- **Course structure**
- **(Activity 1) (Activity 2)**
- **Give away materials at trainings**
- Summary outputs/lessons learned

Wisconsin (August 2012) (Elana and Britta)

- Workshop - Project **link** - Jim Nienhus
- **Course structure**
- **(Activity 1) (Activity 2)**
- **Give Away Materials at Trainings**
- Summary **outputs**/lessons learned

Honduras (August 2012) (Beth and Amanda)

- Survey - Link to Center opening - questions for USAID and others
- **Survey questions** and Course structure
- **Brief summary Mission discussion**

Team: Mark Bell, Amanda Crump, Elana Peach-Fine, Britta Hansen

Appendix 13. PIs and Partners Located in the US.

Horticulture CRSP partners with top scientists

Do you know a Horticulture CRSP partner? To date, Horticulture CRSP has collaborated with exceptional researchers whose expertise lies not only in horticulture, but also in plant pathology, soil science, sociology, biotechnology, agricultural education, tropical plants, resource economics, engineering and more. We continue to further strengthen the capacity of our research network with new collaborators. Each Horticulture CRSP project has partners from developing countries and is led by a principal investigator at a U.S. public university, including:

Jean Ristaino
North Carolina State University
Dept: Plant Pathology
Dir., Global Plant Health Program; 2012 Jefferson Science Fellow

James Simon
Rutgers, The State University of New Jersey
Dir., New Use Agriculture and Natural Plant Products Program

Kate Scow
University of California, Davis
Dept: Land, Air & Water Resources
Dir., Russell Ranch Sustainable Agriculture Facility

Mathieu Ngouajio
Michigan State University
Dept: Horticulture

Cary Trexler
University of California, Davis
Dept: Education

James Nienhuis
University of Wisconsin-Madison
Dept: Horticulture

Kent Bradford
University of California, Davis
Dept: Plant Sciences
Director, Seed Biotechnology Center

James Thompson
University of California, Davis
Dept: Biological and Agricultural Engineering

Bielinski Santos
University of Florida
Dept: Vegetable and Small Fruit Horticulture

Ronnie Coffman
Cornell University
Dept: Plant Breeding & Genetics
Dir. of International Programs; World Food Prize Advisory Council

Diane Barrett
University of California, Davis
Dept: Food Science & Tech.
Site Dir., Center for Advanced Processing & Packaging

Alan Bennett
University of California, Davis
Dept: Plant Sciences
Exec. Dir., Public Intellectual Property Resource for Agriculture

Eunice Bonsi
Tuskegee University
Dept: Plant Biotechnology

Sally Miller
The Ohio State University
Dept: Plant Pathology

Darcy Boellstorff
Bridgewater State University
Dept: Geography

Stephen Weller
Purdue University
Dept: Horticulture and Landscape Architecture

Ricky Bates
Penn State
Dept: Plant Science

Laura Raynolds
Colorado State University
Dept: Sociology
Co-Dir., Center for Fair and Alternative Trade

Michael Reid
University of California, Davis
Dept: Plant Sciences

Steve Fennimore
University of California, Davis
Dept: Plant Sciences

Matthew Kleinhenz
The Ohio State University
Dept: Horticulture & Crop Science

Jeffrey LeJeune
The Ohio State University
Dept: Food Animal Health Research Program

Mywish Maredia
Michigan State University
Dept: Agricultural, Food, and Resource Economics

Robert Paull
University of Hawaii at Manoa
Dept: Tropical Plant & Soil Sciences
Department Chair

Dharma Pitchay
Tennessee State University
Dept: Agricultural and Environmental Sciences

Hans Christian Wien
Cornell University
Dept: Horticulture

Kurt Kornbluth
University of California, Davis
Energy Efficiency Center
Dir., Program for International Energy Technologies

Visit http://hortcrsp.ucdavis.edu for opportunities to partner with Horticulture CRSP.

Horticulture CRSP partner organizations

Each Horticulture CRSP project engages partners in developing countries, including researchers, private enterprise, non-governmental organziations, national agricultural research institutes and universities:

Latin America

- CARE, El Salvador
- Centro de Investigación Agropecuaria San Antonio, Nicaragua
- City Council Chillan, Chile
- Corporación Dinant, Honduras
- Universidad de la República, Uruguay
- Fundación Hondureña de Investigación Agrícola, Honduras
- Instituto Dominicano de Investigaciones Agropecuarias y Forestales, Dominican Republic
- Project Haiti WINNER, Haiti
- Universidad de Costa Rica, Costa Rica
- Universidad de La Molina, Peru
- Universidad de San Carlos, Guatemala
- Universidad Mayor de San Simón, Bolivia
- Universidad Nacional Agraria, Nicaragua
- Universidad Tecnológica América, Ecuador
- University of Concepcion, Chile
- Zamorano University, Honduras

Africa

- AtoZ Textile Mills International, Tanzania
- Abomey Calavi University, Benin
- Agribusiness in Sustainable Natural African Plant Products, Ghana, South Africa, and Zambia
- Agribusiness Initiative Trust, Uganda
- Agro Farm Services, Kenya
- Ahmadu Bello University, Nigeria
- Association des Personnes Rénovatrices des Technologies Traditionnelles, Benin
- AVRDC - The World Vegetable Center, Tanzania
- Council for Scientific and Industrial Research, Ghana
- Crops Research Institute, Ghana
- Egerton University, Kenya
- Food Research Institute, Ghana
- Ghana PolyTechnic Institutes, Ghana
- icipe, Kenya
- Institut National des Recherches Agricoles du Bénin, Benin
- International Institute of Tropical Agriculture, Benin
- International Relief and Development, Zimbabwe
- Institut des Sciences Agronomiques du Rwanda, Rwanda
- Institut Gabonais d'Appui au Developpement, Gabon
- Kangai Tisa Horticultural Farmers Group, Kenya
- Kenya Agricultural Research Institute, Kenya
- Kigali Independent University, Rwanda
- Kigali Institute of Science and Technology, Rwanda
- Kwame Nkrumah University of Science and Technology, Ghana
- Makerere University, Uganda
- Ministry of Agriculture, Food Security, and Cooperatives, Tanzania
- Moi University, Kenya
- Mukono District Council, Uganda
- Mukono Zonal Agricultural Research and Development Institute, Uganda
- Our Lady Queen of Apostles Nkokonjeru Parish, Uganda
- Reach Your Destiny Consult, Ltd., Uganda
- Rural Agency for Sustainable Development, Uganda
- Sandra Kruger and Associates, South Africa
- Scheut Tshilomba, Democratic Republic of the Congo
- Selasie Farms and Groceries, Ghana
- South Eastern University College, Kenya
- Stellenbosch University, South Africa
- Uganda Christian University, Uganda
- Umatara PolyTechnic, Rwanda
- University of Cape Coast, Ghana
- University of Ghana, Ghana
- University of the Western Cape, South Africa
- World Relief, Malawi

South and Southeast Asia

- Acharya N G Ranga Agricultural University, India
- Asian Institute of Technology, Thailand
- Amity International Centre for Post Harvest Technology and Cold Chain Management, India
- AVRDC - The World Vegetable Center, Taiwan
- Bangladesh Agriculture Research Institute, Bangladesh
- ECHO Asia Regional Office, Thailand
- Hanoi University for Agriculture, Vietnam
- Industrial Technology Institute, Sri Lanka
- International Horticulture Innovation and Training Center, India
- Kasetsart University , Thailand
- Link Natural Products Pvt. Ltd., Sri Lanka
- Maejo University, Thailand
- Nepal Agricultural Research Council, Nepal
- Nong Lam University, Vietnam
- Punjab Agricultural University, India
- Rhino Research, Thailand
- Royal University of Agriculture, Cambodia
- Sathguru Management Consultants, Pvt. Ltd., India
- TATA Consultancy Services, India

Horticulture CRSP management entity

Horticulture CRSP is managed by a team at the University of California, Davis, with funding from USAID. Official partner institutions are North Carolina State University, University of Hawaii at Manoa and Cornell University.

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

Appendix 14. Management Entity Response.

Thank you for the opportunity to respond to the External Evaluation Team's review of the Horticulture Innovation Lab. It is clear that the reviewers were very thorough in their evaluation and we are generally very pleased with the findings of this review. We would like to specifically respond to a few of their comments and recommendations.

Recommendation 1: Recruit International Advisory Board (IAB) members with no conflicts of interest.
The reviewers were concerned about potential conflict of interest for some of our board members, including the rotating position for the center directors. We recognize that there could be some conflicts of interest among the board members. This would be especially true of the AVRDC and GlobalHort members who potentially receive funding from the Horticulture Innovation Lab, as well as the center directors. However, our board is advisory in nature and has never voted on any issues pertaining to accepting or rejecting projects. The management entity (ME) listens to the advice of the board members on a range of topics, considers the source, and determines the best way to utilize that advice.

Recommendation 3: Mission Engagement and Review of Proposals before Funding.
We would like to clarify that the Horticulture Innovation Lab already has practices in place to address this recommendation. Every project that is submitted must include a letter of support from the Mission(s) in the countries they propose to work in. Missions are often asked to comment on projects we intend to fund prior to final funding decisions. John Bowman assists with this request. Finally, all of our PIs are requested to meet with the Mission when they visit the countries they are working in, at least once a year and as often as possible. The Mission is notified in advance of the visit and a request for an appointment is made. Only in rare cases does such a meeting not take place. It would assist our ME if we have access to a consistently accurate list of personnel in each Mission with their email addresses.

Recommendation 5: AOR should serve as an intermediary between the ME and the Missions.
The ME appreciates the assistance provided by John Bowman in building relationships with the Missions. We find this very helpful in many instances, especially before the ME has established a rapport with Mission personnel. However, we would not want this to be a requirement for communication with the Missions and preclude direct contact and communication between the Horticulture Innovation Lab ME and Missions. In addition, the ME has expertise that goes beyond our USAID programs that may be of interest to Missions. We are very willing to serve as a resource for the Missions. This may help to foster better collaboration.

Recommendation 7: Extend Postharvest Training Program to other Countries using Regional Centers of Innovation.
The ME agrees with the spirit of this recommendation and we believe that the Centers are well positioned to take on this role. However, due to challenges faced at AVRDC in Tanzania, we have not fully tested the sustainability of the postharvest training and

services center (PTSC) concept because we were not able to sell supplies from the AVRDC center. We recommend that the PTSC be replicated, perhaps at our center in Kenya, to test the full sustainability platform before we replicate to additional sites.

Percentage time of Director and Structure of ME: The reviewers recommended that the Director position be a full time position. We believe that our program can be just as effective with a full time director or a part time director, so long as there is sufficient support from the Associate Director and other ME staff. There are benefits to either structure, and the ME would prefer to decide on ME personnel percentages as a package rather than focusing on one position. There were also questions about the non-linear structure of the ME and a recommendation to develop a linear model. We feel that our model works well and empowers our staff to reach their highest potential. A linear model is not necessarily a better model.

Clarification of Role of Jim Yazman: There are several places in the document (p. 40, for example) where the role of Jim Yazman as AOR is discussed. We do not agree that Jim Yazman's role was minimal. While he was not a horticulturalist, he was very experienced in USAID procedures and was a tremendous help to the ME in many ways, including monitoring and evaluation and reporting mechanisms. He was always a strong champion for our program.

Additional Funding for Centers: We agree with the recommendation to increase funding to the centers and will be developing plans to do this in a way that assures eventual sustainability of the centers beyond the existence of the Horticulture Innovation Lab.

Enhanced Communication among PIs Across Projects and Countries: The reviewers (p. 35) suggested we enhance communications among all of our PIs and collaborators in the U.S. and in host countries. We agree with this recommendation and will be developing mechanisms for such communications.

EMINA bio fertilizer: Several times in the report, the EMINA bio fertilizer is mentioned. Apparently the review team learned about this during one of the site visits. The ME has not been informed through project reports or correspondence about this material, and cautions against plans to disseminate results widely ahead of thorough testing and evaluation.

Plan of Work for next five years: We agree with the recommendations from the review team for the research focus during the next five-year phase. We are pleased that the reviewers support a portfolio including many types of projects, as we have had during the first five-year phase. We have heard some discussion of possibly limiting our program going forward to a small number of countries. If we are going to be limited, we request to have the opportunity to select the counties ourselves based on where we see the strongest needs and opportunities in horticulture.

We are pleased that the reviews suggested additional funding for the Horticulture Innovation Lab program. Increased funding would allow us to make a stronger impact in human and institutional capacity building, along with our research portfolio.

Appendix 7
Report from University of Minnesota

[GROWING POTENTIAL]

AN ANALYSIS OF LEGAL AND POLICY BARRIERS FACED BY WOMEN IN HORTICULTURE IN GUATEMALA, NEPAL, TANZANIA, & ZAMBIA

Hort CRSP
HUMPHREY SCHOOL OF PUBLIC AFFAIRS
UNIVERSITY OF MINNESOTA
Driven to Discover
USAID
FROM THE AMERICAN PEOPLE

GROWING POTENTIAL: AN ANALYSIS OF LEGAL AND POLICY BARRIERS FACED BY WOMEN IN HORTICULTURE IN GUATEMALA, NEPAL, TANZANIA, & ZAMBIA

In partial fulfillment of the Master of Public Policy, Master of Public Affairs,
& Master of Development Practice degree requirements
Humphrey School of Public Affairs
The University of Minnesota

May 2013

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ACRONYMS

ADBL	Agricultural Development Bank Limited
CPA	Comprehensive Peace Accords
GER	Gross Enrolment Rate
GLTF	Gender Land Task Force
FFS	Farmer Field School
UNFAO	United Nations Food and Agriculture Organization
HODECT	Horticultural Development Council of Tanzania
CRSP	Collaborative Support Program
IFPRI	International Food Policy Research Institute
ILO	International Labor Organization
MFI	Microfinance institution
MSME	Micro, small, and medium enterprise
NLP	National Land Policy
NBFI	Non-bank financial institution
SACCOs	Savings and Credit Cooperative Societies
TGNP	Tanzania Gender Networking Program
UNDP	United Nations Development Program
USAID	United States Agency for International Development

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Executive Summary

In 2009 the Horticulture Collaborative Research Support Program (CRSP) at the University of California, Davis was established as part of an effort to reduce rural poverty and chronic malnutrition. Horticulture production provides individuals and families with the opportunity to better their social and economic circumstances through income generation and improved nutrition and health. However, in both agriculture and horticulture women in many developing countries earn lower wages and have access to fewer resources compared to men, despite the fact that women provide much of the labor in these sectors. To support the work of the Horticulture CRSP this report identifies barriers that have the potential to limit the benefits of horticulture production for rural women in four countries: Guatemala, Nepal, Tanzania, and Zambia. This report is divided into two components: a general overview covering broad findings and offering recommendations, and country specific analyses that offer more targeted research and recommendations for each of the study countries.

Research, including a literature review of global trends and country case studies, revealed efforts in all four countries to increase female representation in government, education, and civil society; improve the availability of skills-based training for women engaged in food production; address the complicated issue of land tenure and women's right to property ownership; and extend access to credit and other financial services to rural women. Despite these efforts gender disparity persists in all four countries studied. The key findings are as follows:

Female representation

In each of the four study countries women continue to be underrepresented in critical areas of society. Few women are elected to government positions. Quotas may serve to increase the number of women in government but do not ensure that women appointed to reserved seats accurately represent the views of rural and low-income women or that female officials play an active role in decision-making. While countries have made progress in closing the gender gap in primary school enrollment, females lag behind their male counterparts in secondary and tertiary education enrollment. Lower literacy rates and levels of formal education may preclude women taking on leadership roles in their communities.

Skills-based training

Extension services provide producers with education and assistance that allows them to increase yields, improve produce quality, identify markets, and boost income. Access to extension services and other skill-based training is limited for many rural women. Barriers inhibiting women's equal participation include geographic location, time and mobility constraints, relevance of content, and the predominance of male extension officers.

Land tenure and Inheritance

Even where laws affirm women's rights to land ownership their access to land may be hindered by other factors. Cultural traditions, societal norms, history, religion, and customary law influence land inheritance producing complex webs of regulation and practice.

Access to credit and financial services

The financial services offered by commercial banks often remain out of reach for rural women. These women face challenges in obtaining credit because of geographic location, poor infrastructure, low financial literacy, and lack of sufficient collateral. Microfinance institutions are growing in number but have made only moderate progress in improving financial inclusion.

Recommendations

The consultant team used the above findings along with country-specific analyses to develop a set of recommendations designed to address chronic barriers facing women in horticulture. Since some recommendations address more than one barrier or are nuanced subsets of existing barriers, the recommendations are divided into five categories that differ slightly from those presented in the findings section of the report.

Legal information and services

- Promote greater awareness of legal rights to ensure that women have sufficient information to enable them to make informed decisions.
- Improve availability of legal services by establishing clinics or other mechanisms for providing legal advice and representation that could help women challenge discriminatory practices.

Training and technology

- Bolster existing extension services and work to target training and assistance to women to ensure that women have equal access to the benefits of extension education.
- Use extension to help women access higher stages of the value chain where more value is added and the potential gains are great.
- Increase the number of female extension officers to facilitate improved information sharing with female producers.
- Expand and replicate successful Farmer Field School models that harness local farmer knowledge and encourage collaboration.
- Pursue research to identify best practices for better engaging women in skills-based training for horticulture production that could be used to inform future programming decisions.
- Include low maintenance requirements and adequate instruction in the introduction of labor-saving tools and technology.

Organizations and cooperatives

- Support women's farmers' organizations and cooperatives that expand opportunities for rural women to better operations and participate in markets.
- Build the capacity of women's civil society organizations and facilitate connections among these groups to strengthen their ability to influence public policy.

Financial services

- Expand financial literacy training through programs explicitly aimed at women to support greater financial inclusion and the success of female entrepreneurs.
- Build the organizational capacity of financial cooperatives to increase the chance of long-term sustainability through appropriate risk management.

Market access

- Develop value chain analyses to understand local potential for value-added horticultural products.
- Encourage the establishment of mutually-beneficial direct contracts between companies and women-led producer groups.
- Promote the use of equitable out-grower schemes that offer unique opportunities for smallholder market engagement.
- Cultivate buying agreements with local supermarkets, an intermediary market opportunity with greater security but less stringent standards than those demanded of exports.

A better understanding of the barriers that prevent women from fully realizing the benefits of horticulture production will assist Horticulture CRSP in pursuing strategies aimed at furthering its mission.

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Introduction

This report identifies barriers facing women in horticulture in four Feed the Future countries where the Horticulture Collaborative Research Support Program (CRSP) works: Guatemala, Nepal, Tanzania, and Zambia. Understanding these barriers will enable the Horticulture CRSP to carry out its mission – to improve food security, nutrition, health, and enhance income opportunities through horticultural development – more effectively (Bailey, 2009; Horticulture CRSP, 2013). Women working in horticulture production in these countries earn lower wages and have access to fewer resources than men, despite providing a majority of the sector's labor (Bailey, 2009). Closing gender gaps that inhibit women's ability to grow food is an important strategy for improving the efficacy of the Horticulture CRSP's projects and for reducing poverty and hunger in developing countries (Sustainable Development Department of the Food and Agriculture Organization of the United Nations (SDD FAO), 2013).

Literature focused on horticulture is limited; research on global trends in agriculture provides a substitute for identifying barriers facing women in food production. Female representation, skills-based training, land tenure and inheritance, and access to credit and financial services are four common themes among these barriers. These themes manifest in different ways in each of the four study countries, informed by unique histories and legal policies. The challenges facing women in horticulture reflect legal and policy barriers as well as social, cultural, and economic obstacles.

Female representation

Inadequate female representation in every aspect of society affects how women benefit from government, education, and employment. This report analyzes female representation in a variety of sectors, including government, cooperatives and associations, economy, and education to identify where representation is deficient and how this lack of representation affects women in horticulture. Some countries have made legal changes in recent years that ensure a certain percentage of decision makers are women and have recognized the need to increase the number of women participating in various levels of education. Representation among community-based women's groups – such as cooperatives, farmers' associations, or marketing groups – allows women to build social capital and a robust producer network. In these sectors female representation may provide opportunities for reducing gender disparities (Tamerius, 2010).

Skills-based training

Addressing women's lack of access to agriculture and horticulture extension services is critical to improving women's farm yields and increasing their incomes. Women's low literacy levels, lack of time, and limited mobility often hinder their participation in skills-based training (International Food Policy Research Institute (IFPRI), 2008). A dearth of female extension workers further inhibits women's participation in extension education for social and cultural reasons. Tailoring these services to meet the unique needs of women farmers will expand the benefits of improved farm methods, crop varieties, and new technologies (IFPRI, 2008).

Land tenure and inheritance

Despite being responsible for growing a majority of the world's food supply women own one percent of the land (SDD FAO, 2013). Limited access to land poses a significant barrier to women working in horticulture, affecting the size of their fields and the quality of the land they farm. Without land title women may choose not to invest in land improvements or plant perennial crops. Marital property rights, rights and access to legal transactions, inheritance practices, credit access, and a woman's ability to appeal to a judicial system affect her access to land (SDD FAO, 2013). Women who have control over land tend to have greater financial independence and are more successful at providing for their families and increasing the productivity of their farms (International Center for Research on Women, 2012).

Access to credit and financial services

Owning land provides farmers with the fixed assets necessary to gain access to credit. Without access to credit women farmers are unable to buy equipment, high-quality seed, and fertilizers that help them improve farm yields. Limited access to credit and inputs also makes it difficult for women to participate in more lucrative value chains or in more lucrative parts of the value chain, particularly those production steps that add value between the planting of a seed to consumption of the final product (Mehra & Rojas, 2008). To address rural women's unique financial needs, governments, organizations, or banking institutions must find ways to provide access to insurance, savings, and credit opportunities (El-Fatal, 2012).

This report provides a brief summary of project methodology, a general overview of research findings, broad recommendations for the future, and country-specific information and analyses. By identifying the obstacles and possible solutions to the challenges that rural women producers face, Horticulture CRSP will be better positioned to meet the unique needs of these women in the countries in which it operates.

Methodology

This report identifies the legal and policy barriers that pose challenges for production, processing, marketing, and the sale of horticulture goods for women in Guatemala, Nepal, Tanzania, and Zambia. In addition, the report seeks to address the social, cultural, and economic obstacles affecting policy implementation, identifying these barriers and providing recommendations to support the work of the Horticulture CRSP.

Our five-person team of consultants, henceforth referred to as the team, conducted research over a three-month period. The team initially explored global trends in horticulture and then focused on barriers across four themes in each of the study countries: lack of female representation throughout society, access to skills-based training, land tenure and inheritance, and availability of credit and financial services. Where horticulture data was missing the team utilized information regarding agriculture and sought to minimize inclusion of data related to staple cereal crops. The team synthesized global trends in a literature review and engaged in extensive research focusing on the barriers in each country. Secondary sources included peer-reviewed journal articles, white papers and other non-government organization-based research, as well as websites and news publications. These sources offered varying perspectives that helped the team cultivate a holistic understanding of the study countries and critical barriers as well as guided the team in developing appropriate recommendations. The team primarily employed secondary sources to conduct research and analysis and then discussed findings with individuals who had experience in the field in the study countries. The team used these primary sources to corroborate, contextualize, or provide an alternative viewpoint to findings from secondary sources.

Each member of the team was given a specific area of focus but engaged with information from all research topics, study countries, and global trends. This division not only permitted the team to pursue targeted research but also allowed for information sharing and a collaborative review process. This process enabled each member of the team to benefit from the findings of other team members while retaining a specific focus. Information sharing was important in targeting statutory barriers since many countries have eliminated most explicitly discriminatory language from their laws. Specific barriers and initiatives designed to overcome them varied among the study countries, helping the team consider recommendations from multiple perspectives. This allowed the team to develop richer recommendations than would otherwise have been possible.

Limitations

The team faced a number of challenges while researching and drafting this report. One key limitation to the study was the accessibility and availability of data. For instance, there is limited analysis available on the effects of recent efforts to remove discriminatory language from statutes in each of the study countries. In addition, while there is a substantial body of literature on women in agriculture in the developing world, finding data specific to horticulture was more challenging. Where countries operate with multiple legal systems, giving standing to both policies from government bodies and local customary practices the team found it difficult to interpret the full effects of discrimination. The details of these customary laws are not always well documented and may vary significantly across regions, ethnic groups, clans, and tribes. Additional research is needed to understand how best to negotiate two separate but valid legal systems.

Research on Guatemala and Nepal often linked the plight of women with certain marginalized populations that face persistent discrimination. This made it difficult for the team to distinguish between disparities associated with gender specifically and those that result from the limited economic, social, and political capital of these groups.

The team sought primary sources with country-specific knowledge to confirm secondary research data and offer additional insight. Reaching appropriate experts proved difficult because of geographic restrictions and time limitations. In one case, a language barrier complicated this process. Due to the project's short time frame, the team was unable to assess certain topics, such as specific agricultural policies and tax laws that influence horticultural development. Similarly, the team only assessed subjects such as women's participation in education, in brief.

FINDINGS

The following section provides an overview of key research findings. The findings listed below highlight common trends and provide a foundation for the team's final recommendations. Consistent with the organization of the paper, the findings discussion centers around barriers categorized by four key themes: female representation, skills-based training, land tenure and inheritance, and access to credit and financial services.

FEMALE REPRESENTATION

In each of the four study countries few women have been directly elected to government office. Female representation in government office in Zambia declined in the 2011 elections from previous years. Tanzania's October 2010 election yielded only 20 directly elected female members of parliament, accounting for roughly 8.3 percent of contested seats (United Nations Development Programme (UNDP), 2010). All four countries have attempted to increase the number of women represented in government. For example, the governments of Tanzania and Nepal have established quotas that reserve a specified number of seats for women (Falch, 2010; International IDEA, Inter-Parliamentary Union and Stockholm University, 2011). While these quotas offer the appearance of greater female representation, to be granted a quota position women often must be members of the elite and curry favor with powerful political party affiliates. As a result appointed women may share little in common with the broader female population. Beyond the implications for gender-sensitive policy development, understanding the viability of female candidates in elections provides insight into the level of political capital available to local women. In Guatemala, women in politics are often "tokenized," meaning that they are accepted into political parties in an effort to secure additional public support but only assigned marginal roles that lack influence (Montenegro, 2002; Lopez, 2009; National Democratic Institute (NDI), 2013). While the team found it difficult to find concrete evidence that female government officials ensure that women's issues are given greater consideration, international organizations often stress the importance of female political representation with respect to local governing bodies, such as land councils.

Strong government commitments to reducing disparity have contributed to a narrowing of the gap between males and females in primary school attendance in recent years. However, many rural women complete neither secondary school nor advance to tertiary educational institutions. Adult literacy rates among women are often lower than their male counterparts. Part of this effect reflects cultural norms. As girls age their school attendance drops off dramatically (World Bank, 2013a). For example, in rural areas of Guatemala nearly 66 percent of girls drop out of school before completing the third grade (Hall and Patrinos, 2006). Nepal's gross secondary school enrollment rate is 48 percent for boys and 35 percent for girls (UNESCO-UNIS, 2012).

Research suggests that farmers' associations and cooperatives provide an important means of supporting smallholders in boosting productivity and accessing markets (Jones, Smith, & Wills, 2012; World Bank, Food and Agriculture Organization of the United Nations, & International Fund for Agricultural Development, 2009). Although data available on these types of organizations operating within the four study countries are limited, these organizations hold particular promise for the advancement of rural women who benefit from the facilitation of social networks and pooling of economic capital (Davis, 2000). Women's civil society organizations also play an important role in advancing women's rights broadly. For instance, in Tanzania and Guatemala women-focused civil society organizations have secured a greater voice in the political arena. During Tanzania's land reform efforts in the late 1990s, local groups advocating gender equality influenced the debate on major land reform legislation (Tsikata, 2003). In Guatemala women's civil society organizations have gained influence with the country's dominant political parties.

Skills-based Training

While the four study countries have distinctive extension systems as well as varying levels of technology access and technological proficiency, rural women in each country face critical barriers in the area of skills-based training. Rural women's participation in training through extension services was hindered by a few key factors including geographic location, relevance of training content, conflicting demands on time, and predominantly male extension officers.

Women are often concentrated in the lower-skilled and lower-paid sections of horticulture value chains. The tasks they perform are necessary but generally require neither high levels of education and training nor do they provide opportunities for advancement. Extension services do not address areas of the value chain where women are mostly highly concentrated. As a result women neither receive training to advance their skills in low end production areas nor do they benefit from training that enables women to move up the value chain. With little experience and training, women do not garner the full range of potential benefits of horticulture production (Collet, Gale, & Walker, 2009; United States Agency for International Development (USAID), 2012). In Guatemala the division of labor within households reflects culturally-ascribed gender norms and encourages women's participation in low-skilled activities while men dominate later stages of production, including sales and marketing. Although most smallholders in Zambia cultivate horticulture products, only a small percentage of these households sell to formal, high-value markets. Farmers cannot advance operations without knowledge of the composition and functioning of formal markets, market demands, and value-added processing (Hicaambwa & Tschirley, 2006; Sitko, Chapoto, Kabwe, Tembo, Hichaambwa, Lubinda, Chiwawa, Mataa, Heck & Nthani, 2011).

The multitude of household tasks demanded of women influence their schedules and mobility. Training opportunities often fail to consider geographic and time limitations specific to women. Thus women may not engage when efforts are not made to schedule workshops and training sessions during times and in locations conducive to their involvement. When women do not participate actively, they do not obtain all of the information provided. Although extension agents may operate under the assumption that knowledge is shared within the household, research from all four study countries indicates that men frequently fail to communicate information learned from extension agents with their wives and other female family members (Republic of Zambia (GRZ), 2006).

In many countries the majority of extension workers are men. Educational disparities at the secondary and tertiary levels contribute to the gap between male and female extension workers. Research has shown that some women smallholders prefer female extension officers (Due & Temu, 1997; Wiebe, 2000). Male extension officers may attribute less value to training women or may confine instruction to a specific set of activities (Republic of Zambia, 2006; Quisumbing, Agnes R.; Brown, Lynn R.; Feldstein, Hilary Sims; Haddad, Lawrence; Pena, C., 1995; Collet, Gale, & Walker, 2009). To the extent that religious or cultural norms prevent open communication, knowledge-sharing, and questioning between male extension officers and female producers, training and hiring additional female extension officers will be crucial. Although religious practices are not a significant barrier to men and women's interaction in Guatemala, strong and dominant cultural norms exist around the role of women in agriculture. Some countries, including Tanzania, have sought to increase the number of female extension officers.

Land Tenure and Inheritance

There is a large and growing body of literature exploring issues of land tenure in each of the study countries. Despite ample study this topic yields more questions than answers. In many contexts land ownership is a complex challenge – heavily influenced by history, religion, and cultural practice. A number of international organizations have encouraged land reform as a means of realizing economic growth and agricultural sustainability, with varying levels of success. The limited viability of this strategy suggests that land privatization may not always be the best approach. While individuals in study countries may not identify formal deeds to land as a major barrier, gender disparity is exacerbated in circumstances where titling for property is common and men are granted formal deeds, while women's claims are less recognized. Further, titled land is a common prerequisite to obtaining credit.

Customary laws and traditional practices frequently govern land inheritance, making it a complex issue in each of the four study countries. Land inheritance laws disadvantage Nepali women and are conditional on age and marital status (Asian Development Bank, 1999). Many of Tanzania's communities are patrilineal with customary laws that prevent or limit women's inheritance of clan land (Carpano, 2010). Land under customary tenure in Zambia belongs to a clan or community. In the event of death or divorce Zambian women may suffer land grabbing, technically allowed by law, when clans choose to reallocate land to male relatives (Machira, Bweupe, & Chiyombwe, 2011; Social Institutions and Gender Index (SIGI), 2012).

In countries where laws prohibit gender discrimination and provide the opportunity for joint spousal registration, lack of awareness or cultural stigmas may affect implementation. Even when women have a strong understanding of their rights they may feel uncomfortable voicing opposition to common practice. In Zambia married women are unlikely to be awarded their own customary landholding unless they receive permission from their husbands (Machira et al., 2011). Without access to legal services, women cannot effectively challenge discriminatory practices.

Access to Credit and Financial Services

The financial services provided by commercial banks are often out of reach for rural women in the four study countries due to geographic location, minimum deposit requirements, considerable paperwork, and demands for formal identification. Policies of financial institutions, including restrictions on unsecured loans and minimum collateral and deposit requirements, also limit women's access to financial services. Governments can support women's access to credit through land tenure and inheritance policies that encourage female ownership of land. In Zambia access to customary land through a male relative is often inadequate for securing loans that stipulate land as collateral (Machira et al., 2011). A growing number of informal institutions offer opportunities to extend credit access to underserved rural and agrarian populations. The success of these institutions may depend on strengthening their organizational management and increasing the financial literacy of the rural customer base.

Recommendations

Based on the above research findings, country-specific initiatives, and the potential scope and capacity of Horticulture CRSP's work the team formulated a range of recommendations aimed at improving women's ability to benefit from horticulture development. Some suggested actions have broad applicability in the four study countries. Others are country-specific or take on unique dimensions in different country contexts. The team would advocate engaging in thorough stakeholder analyses to explore the potential for both intended effects and unanticipated consequences on a variety of actors prior to adopting any suggested measures. The recommendations are divided into five categories: legal information and services, skills-based training, organizations and cooperatives, financial services, and market access.

Legal Information and Services

Promote greater awareness of women's legal rights

Each of the four study countries has made considerable progress in eliminating provisions from national policy that explicitly discriminate against women. Where national laws affirm women's right to property ownership, such as in Tanzania and Zambia, efforts to expand awareness of these policies among both men and women could improve women's access to land. Laws in Tanzania and Zambia allow married couples to register property jointly. Providing men and women with a full understanding of the laws governing land registration would allow spouses to make informed decisions. In some instances the benefits of joint registration extend beyond women's increased financial security. For instance, the Government of Nepal offers a waiver of registration fees if land is registered in a woman's name.

Improve availability of legal services by establishing clinics or other mechanisms for providing legal advice and representation

Even where women are informed of their legal rights to land and other assets they may be unable to challenge discriminatory practices. Facilitating access to legal assistance could empower women to seek stronger positions in household negotiations or even through formal litigation. Legal services play a critical role in helping female entrepreneurs navigate the challenges of business ownership, particularly when it comes to registration, licensing, and taxation.

Training and Technology

Bolster existing extension services and work to target training and assistance to women

Extension services offer critical technical assistance to women engaged in horticulture, enabling them to increase productivity, improve quality, fend off pest and disease, and identify markets. Rural women in the four study countries often face significant, competing demands for time that limit their ability to seek out and participate in extension services. By polling women in communities to determine the most convenient times and locations for workshops and other training sessions, extension services would improve engagement. For instance, single-day training may stimulate greater interest from women. In Guatemala customizing training sessions to incorporate family units instead of individuals has proven beneficial. Similarly, extension should assess the content of offerings and seek to address the needs of local women. Providing extension officers with instruction that allows them to adapt training to women and arming extension officers with information regarding the importance of reaching women will improve the likelihood of successful female inclusion. Encouraging governments to devote additional funding to extension activities could allow more resources to be directed to programming that meets the unique needs of rural women. In Guatemala, some horticultural export firms operate training workshops specifically for women in response to the feminization of the workforce. Evidence suggests that the effects of this private sector training on participants extended beyond the field to improve women's bargaining position in the household (Hamilton, Asturias de Barrios, Sullivan, 2002).

Use extension to help women access higher stages of the value chain

Extension's support for women should move beyond basic production assistance to help women build networks and find viable markets. Farmers trained in simple processing techniques are better positioned to add value to horticulture products. This additional value compensates for limited market access in rural areas and poor infrastructure. Extension services should combine information about markets with crop-specific information to help women select the most appropriate crops given time, mobility, and input constraints.

Increase number of female extension officers

Achieving an increase in female extension officers will require governments expanding pathways for women to obtain employment through extension services. Vocational extension training remains out of reach for many rural women due to the associated cost and time commitment. Further, access to this specialized training occurs through select institutions, frequently located in urban areas, thus requiring considerable travel. By providing decentralized training programs or by making scholarships available to rural women, governments can increase the number of female extension officers. Governments could require recipients of either the decentralized training or scholarships to serve marginalized communities for a specified period of time as part of their participation. Agriculture ministries would boost interest and awareness by facilitating training and recruitment drives in underserved areas, regions with above average female participation in agricultural activities, and communities with strong cultural barriers preventing comfortable exchange between men and women.

Expand and replicate successful Farmer Field School models

The Farmer Field School (FFS) approach seeks to capitalize on local farmer knowledge and expertise by facilitating group-based learning and sharing. While frequently less formal than government-sponsored extension services, the FFS model can be a cost-effective method of extending resources and information to more remote areas and encourage community-supported networks and ongoing collaboration. Regions of Tanzania and Nepal both have experience with the FFS approach.

Pursue research to identify best practices for better engaging women in skills-based training for horticulture

A review of projects that have successfully integrated female participants and provided training that meets women's needs should be used to inform future projects. This research should include collecting data and information about training formats, communication methods, technology utilized, general demographic characteristics of women, and specific inclusion tactics.

Include maintenance and instruction in the introduction of tools and technology

In the production of some horticulture crops, instruments and equipment to assist in seeding, cultivation, and processing provide women with additional time and allow smallholders to expand operations or move along the value chain. In all four study countries women are concentrated in time-consuming and labor-intensive sectors of horticulture production; this leaves women with little time to perform other tasks or engage with other stages of the value chain. In some areas, laborsaving advancements are needed, but introduced technology must be of high quality and easily repairable. Rural areas with limited market access and underdeveloped infrastructure require technologies that are easily adaptable and do not require regular inputs or outside maintenance.

ORGANIZATIONS AND COOPERATIVES

Support women's farmers' organizations and cooperatives

Farmers' organizations and cooperatives serve a variety of crucial purposes, providing storage capacity, fostering networks, and putting forward cash advances. In addition, these groups aggregate product, build markets and increase negotiating power with buyers. Such organizations, which are often crop-specific or have a regional focus, prove particularly valuable when small yields rank among the greatest barriers to market access facing female producers. Providing additional resources and technical assistance to existing organizations will help these groups encourage productivity and market access. Furthermore, these organizations play an educational role, offering supplemental training in growing techniques, processing, and even small business ownership. Women-led farmers' organizations and cooperatives are an ideal target but organizations with inclusive membership and diverse leadership offer another means of achieving the same goals. Women organized into farmers groups in Zambia received greater attention from public extension. Given Zambia's highly rural and decentralized structure, organized groups are often the only mechanism for accessing financial and agricultural inputs.

Build capacity of women's civil society organizations and facilitate connections among groups

Civil society organizations play a critical role in influencing public policy. Working to strengthen existing organizations or groups with strong community presence, particularly those that emphasize agriculture, horticulture, female representation, and women's participation in the labor force, can affect change in policy or local institutions. These organizations also facilitate women's access to social and economic capital, pooling limited resources and creating agency. Since the late 1990s women's organizations have been on the rise in Guatemala. The National Union for Guatemalan Women's initiative to encourage women's participation in municipal councils has yielded some success. In Nepal women's advocacy groups effectively lobbied for greater political representation, leading to passage of a mandate that women comprise one third of government representatives. Supporting these efforts can create a sustainable cycle where women gain agency, represent their own concerns, and identify transformations that truly benefit women.

Financial Services

Expand financial literacy training through new and existing programs aimed at women

When armed with more information women are better positioned to make prudent financial decisions and seek access to financial services. While financial services offerings continue to expand penetration may be limited by lack of financial literacy. In addition to underscoring the potential value of financial services targeted training programs could help women meet critical prerequisites, including filling out paperwork and obtaining formal identification cards. This training could be offered in tandem with horticulture-focused workshops. There are a variety of alternative options for delivering such instruction. One is to work with government-led extension services to see that financial literacy content is added to existing curricula. Another is to encourage targeted outreach through the growing network of institutions offering financial services. In Tanzania and Zambia these include Savings and Credit Co-operatives and other microfinance institutions. This training could be spearheaded or facilitated by farmers' organizations or women-focused civil society organizations. Notably, working with extension services or farmers' organizations would allow the efforts to be tailored to the needs of women in horticulture, offering specific guidance in creating budgets consistent with planting and harvesting schedules. While local financial institutions might be the most effective in ensuring that these efforts result in women's increased financial inclusion, producers might see these organizations as less trustworthy given their vested economic interest. In areas where real opportunities for expansion and market access exist farmers would benefit from supplemental financial training focused on entrepreneurship.

Build the organizational capacity of financial cooperatives

Many developing countries, including the four examined for this study, have witnessed considerable growth in the number of small institutions offering financial services. This growth trend is an important development since the services of commercial banks often remain out of reach for rural women because of geographic location, minimum deposit requirements, demand for proof of identity, or overwhelming paperwork. However, in many cases this surge in less formal financial institutions has not led to a dramatic rise in rates of financial inclusion. While increasing financial literacy will expand the potential customer base, improving the effectiveness of these institutions will bolster their reputation. Providing capacity building to help these institutions increase transparency, appropriately manage risk, and communicate with stakeholders will raise the quality of the services offered and improve the chances for long-term sustainability.

Market Access

Develop value chain analyses to understand local potential for value-added horticultural products

Context-specific value chain analyses can inform critical decisions by local producers and farmers' associations, providing a foundation for individualized or group business plans and budgets. Tapping local resources for this work would ensure that context is given greater consideration in the analyses and increase the likelihood that materials are kept up to date. While in-country firms may offer these services, partnering with local universities provide another option. Where this research exists, as in Zambia, sharing information with producers should be prioritized. Building these partnerships and connections would promote ongoing research and allow farmers to benefit from the findings.

Establish direct contracts between companies and women-led producer groups

In Guatemala and Zambia, where export-focused horticulture has a stronger presence, exploring partnerships to link producers to businesses may be of particular benefit to women. Companies often contract exclusively with men despite women's critical role in production. Forming partnerships and networks that provide a place for women at the negotiating table would give women a voice in contract terms. Companies, particularly those that market to populations in the United States and Western Europe, may find marketing advantages or an opportunity to realize corporate responsibility goals in implementing fair agreements to source from women producers. Building connections between strong producer groups and potential buyers could facilitate mutually-beneficial direct purchasing relationships.

Promote the use of equitable out-grower schemes

Out-grower schemes link individual producers or groups of farmers with businesses that process horticulture goods for further sale. While partner businesses involved in these arrangements will seek to maximize their profit, they also provide training, technology, and other support to farmers in the interest of guaranteeing produce of consistent quality and quantity. In cases where farmers' organizations have sufficient quantity these agreements afford unique capacity building potential. Clear contracts that entice companies but also ensure that farmers will have a market for their product are important. Out-grower schemes have met with some success in Zambia; in cases where this model failed the needs of both producer and purchaser were not addressed through clear and equitable contracts.

Cultivate buying agreements with local supermarkets

A number of large supermarket chains are expanding operations in developing countries. Local branches of these supermarkets demand a certain quality and quantity of product that is unrealistic for some producer groups. For others local supermarkets provide a chance to tap a growing intermediary market. This intermediary market boasts less stringent standards and fewer infrastructure needs than necessary for export but offers greater security than afforded by other local markets. The majority of Zambia's produce is sold in open-air markets but linkages between smallholders and supermarkets represent an important opportunity for accessing higher-value markets. Working with formalized supermarkets provides farmers with experience that can eventually facilitate transition to export markets. In Zambia many supermarkets have branches that process fresh produce for local sale or export markets. Connecting with supermarkets creates new opportunities for sale of produce to both the supermarket and processing branches of the business.

Guatemala

Guatemala is a lower-middle income country in Central America that shares its borders with Mexico, Honduras, Belize, and El Salvador. Approximately 40% of its 14.3 million inhabitants are indigenous. Agriculture is a large driver of the country's economy, as it comprises about 66% of all of Guatemala's export earnings, and 40% of all employment. Guatemala is a major exporter of non-traditional agricultural products, more than doubling the volume of its fruit and vegetable exports from 1992 to 2001. Approximately 54% of Guatemala's total population lives below the poverty line. However this rate is much higher in the rural areas and the Highlands, with 70 to 80% living below the poverty line. Due to a history of economic, social, and political exclusion, the indigenous population tends to be the most vulnerable group in Guatemala in terms of malnutrition, poverty, and high stunting rates. And among these groups, female-headed households are often the most destitute.

Key Findings

- The most vulnerable populations in Guatemala are the country's indigenous. Constituting over 40 percent of the population, these groups have the highest rates of poverty, malnutrition, and stunting. The indigenous populations are overrepresented among the uneducated, with lower literacy rates and higher drop out rates, limiting participation in high-level decision-making roles.
- Guatemala has one of the lowest rates of female legislators in Latin America. Only about 24 percent of deputies in Congress are women. Women are even more underrepresented at the local level. In the 2011 election, out of 333 mayoral races only seven women were elected. As a result, women's rights and needs are not prioritized.
- There is disparity in women accessing skill-based or vocational training. When agricultural training sessions are offered in rural areas, over 70 percent of participants were men. Subsequently, men took greater control of the smallholder farms, while women provided more unpaid labor to the farms. This access barrier stems partly from cultural norms about the role of women in production, and a lack of female extension officers.
- The rise of non-traditional agricultural exports in Guatemala has led to the increase of large corporations contracting with rural farmers. Companies tend to contract with men, in part, because these companies benefit from the unpaid labor of the man's family. Training through these companies typically targets men. Subsequently, women often remain invisible and unrecognized in interventions that are aimed at upgrading producers in the value chain.
- Indigenous populations are disproportionately underrepresented among landowners, owning only 24 percent of the Guatemala's land. Landlessness limits entry to modern value-chains.
- Smallholder, indigenous farmers often lack the necessary resources and must rely in credit to

invest in the farm equipment necessary to compete in horticulture markets. However, access to formal loans is limited for indigenous women. The only rural bank in Guatemala, Banrural, grants very few loans to women for agricultural activities; indigenous women are generally unable to obtain loans because they lack title deeds or other assets that serve as collateral.

Recommendations

- Provide training that increases women's knowledge in higher value-added steps of the value chain. Women in Guatemala are concentrated in low-skilled, labor-oriented tasks like planting, weeding, and harvesting. Training to support women should be targeted to their specific needs: providing information about technology and tools related to production; building access to network and enterprises to encourage income earning opportunities; education on planning and controlling finances; and knowledge on accessing markets to sell their products. Involvement in higher levels of the horticulture value chain is commonly perceived as a "male activity". As such, training should also be targeted at both women and men to encourage women's engagement with these advanced stages of the value chain.
- Target extension training at entire families or households, rather than individual heads of households. Farming in rural Guatemala is typically a family affair. Yet over 70 percent of people who participate in extension services are men. It is often assumed that this knowledge would be passed on to the whole household, but this is usually untrue. Training that target the entire household could increase productivity of all family members.
- Provide more vocational and skills training in rural regions. Both women and indigenous populations are typically excluded from vocational and skills training; lack of proper infrastructure in rural areas limits these groups' access to relevant training. Extension services should also be adapted for these populations by making sure these training are offered in a variety of indigenous languages, taught by female extension officers, and held for a duration of one day to accommodate women's schedules.
- Connect women farmers with strong civil society organizations. Since the late 1990s, women's groups have been gaining prominence in Guatemala. Linking farmers to women's networks that are strongly developed could provide examples of effective organizations and encourage women farmers' participation in skills training, cooperatives, and advocacy.
- Encourage export-oriented produce companies to contract with women or entire households. Export-oriented horticulture companies tend to contract with men and benefit from the unpaid labor of their households. Both spouses should be included in the language of the contract and wages should be adjusted accordingly. In this process, women may have better access to skills training for higher levels of the value chain.
- Support institutions that tailor loan conditions to accommodate smallholder capabilities and resources. Smallholders typically invest through intermediaries that specialize in providing credit to the agricultural sector. Formal financial institutions could benefit from the business of smallholders by targeting these groups. Institutions that already work with these groups, such as Banrural, should be encouraged to actively reach out to the female and indigenous population. To reduce risk for lenders, the Government of Guatemala should engage in risk transfer programs. These programs would incentivize lenders to lend to more disadvantaged populations as risk would be reduce via credit guarantee funds or other risk-subsidizing mechanisms.

Female representation

Indigenous representation

In Guatemala many of the current disparities faced by women can be tied to active discrimination and exclusion of the country's indigenous populations. This group tends to be the most vulnerable in terms of malnutrition, poverty, and high stunting rates. Among these groups, female-headed households are often the most destitute. Approximately 40 percent of Guatemala's population is indigenous and 80 percent of the indigenous population is settled in rural areas of the country, especially in the Western Highlands of the region (Central Intelligence Agency (CIA), 2012). The poverty rates in these regions are much higher compared to the rest of the country, with 70 to 80 percent of the population living below the poverty line (Minority Rights Group International (MRGI), 2008; World Bank, 2012b; CIA, 2012).

The history of active economic, social, and political exclusion of indigenous populations was exacerbated by Guatemala's civil war, which ended in 1996 (Hamilton, Asturias de Barrios, & Sullivan, 2002). During the civil war, the indigenous were actively targeted by the military regime, as some indigenous initially supported the leftist guerilla movements hoping these groups would address the economic and political marginalization of the indigenous communities. Over 200,000 Guatemalans were killed or forcibly disappeared during the civil war; of those who were identified, over 80 percent were indigenous. In addition, large percentages of the indigenous population were left displaced and unable to support themselves (Center for Justice and Accountability, 2013; National Democratic Institute (NDI), 2013). Considering the historical exclusion of Guatemala's indigenous populations and the further discrimination faced by indigenous women in the country, the subsequent discussion of barriers women face in realizing the benefits of horticulture production are primarily focused on indigenous women.

Legal Representation

In Guatemala both women and indigenous populations have been historically excluded from the political realm. Often times this was through direct policy means such as actively prohibiting women from participation in the electoral process. Literate women were only granted the right to vote in 1945 and illiterate women in 1965, although illiterate women's right to vote was rescinded during the civil war and not reinstated until the new constitution was established in 1985 (NDI, 2013; Center for Justice and Accountability, 2013; United Nations High Commissioner for Refugees (UNHCR), 2008). Interrupted opportunities to participate in electoral politics have hampered the development of a participatory democratic tradition among women. Indigenous women, who are overrepresented among Guatemala's illiterate population, have had even fewer opportunities to cultivate a culture of engagement with electoral politics.

There have been recent efforts by the Guatemalan government, local civil society, and international organizations to create an environment of equal representation in government. The number of women voting is increasing rapidly. Guatemalan election authorities, with the help of UN Women, carried out a campaign to decentralize voting stations prior to the 2007 and 2011 general elections to ensure both women and rural voters were able to participate in the electoral process. In 2011 women represented the majority of registered voters for the first time, with 51 percent female voters compared with 49 percent male voters (NDI, 2013; United Nations Entity for Gender Equality and the Empowerment of Women, 2011). Similar effects have not been seen among indigenous voters, who only saw minimal increases in voting. While constitutional law permits universal suffrage, indigenous people's voting rights are still constrained by exclusionary social practices such as tedious voter registration requirements, elections scheduled during harvest season, and inadequate transportation from rural areas to the voting stations (Cojti, 2011; Lopez 2009; Montenegro 2002; NDI, 2013; MRGI, 2008).

Following the civil war Guatemala actively sought to eliminate formal discrimination from its Constitution. Article four of the Constitution does not have specific provisions about gender equality but does include language regarding equality for all individuals. In addition, the Constitution was updated by decree to criminalize discrimination in 2002. The Constitution includes a blanket non-discrimination clause; however, this clause does not specifically mention discrimination on the basis of gender. Despite there being anti-discriminatory legislation gender discrimination still persists, as prosecution of discriminatory acts is contingent on the government's willingness to act. However, this has not been prioritized due strong patriarchal traditions in the judicial administration (Cojti, 2011; Committee on the Elimination of Discrimination Against Women, 2008; NDI, 2013).

Guatemala has faced an unstable political environment since the end of its civil war; its political institutions are weak and corrupt, and this inhibits the ability to impose major policy changes (Montenegro, 2002; NDI, 2013). De facto discrimination continues to exclude the indigenous communities from the country's legal and political systems (Cojti, 2011; NDI, 2013). For example, the new Constitution recognized the existence of indigenous groups and provided for the state to respect their rights to use indigenous languages, traditional dress, and socially organize. However, this law has still not been officially enacted. Without formal enactment of the right to socially organize, indigenous groups face strong limitations in organizing new political parties. This is particularly problematic as existing political parties often fail to address the unique needs and demands of indigenous communities. In these political parties indigenous people are only given marginal roles, and lack any real decision-making power (Cojti 2011; Lopez 2009; Montenegro, 2002; MRGI, 2008).

Representation in government

Despite recent surges in numbers of women voting in Guatemala, females are still underrepresented in elected positions. Guatemala has one of the lowest rates of female legislators in Latin America. Of the 158 deputies elected to Congress in the 2011 election, only 21 were women and 18 were indigenous. In the 333 mayoral races held the same year there were no indigenous candidates and only seven women were elected (Cojti, 2011; Montenegro, 2002).

The Guatemala's democratic system operates in an arena in which a small number of dominant political parties have control, which reduces participation of other existing parties or the emergence of new political parties. Without competition pressuring dominant parties to serve marginalized populations, women's opportunities for participation in legislative decision-making are limited. Although political parties are open to men and women equally by law, this often does not occur in practice. As many women's groups are increasingly organized around political aims and are able to have strong influences on citizen viewpoints, many political parties have a growing interest in addressing the concerns of the female demographic. Although women's organizations promote voter turnout, they do not have the ability to nominate women as candidates for Congress, as this falls to political parties (Grobakken, 2005; Lopez 2009; Montenegro, 2002). As a result, there are relatively few women in Congress, and women's rights and needs are not prioritized. Many of the current parties include some women but inclusion in the party does not translate to participation in Congress. Women are typically given marginal roles and lack any real decision-making power. National political parties often restrict indigenous members' access to decision-making posts within the party's structure, thereby effectively excluding them from exerting influence in the wider political arena (Lopez, 2009; Oxfam Canada 2011; Plant, 1998).

SKILLS-BASED TRAINING

Access to training and technology in rural Guatemala

In Guatemala increasing agricultural productivity is an important strategy in reducing poverty. Agriculture accounts for almost 40 percent of employment (CIA, 2012). This number is significantly higher for the mostly indigenous, rural population with approximately 70 percent participating in some sort of crop production, typically smallholder family agriculture (World Bank, 2012b). In the past these ventures were typically subsistence based, but with Guatemala's recent agricultural export boom (increasing by 78 percent since 2000), market-oriented production is expanding in indigenous communities. Subsequently, there has been a significant modernization of production methods in order to become more competitive in the global market (Barham, Carter, & Mesbah, 1996; International Fund for Agricultural Development (IFAD), 2012).

For the rural population, especially the indigenous groups, there is a significant gap in both access to new means of production and knowledge of how to use them (Hamilton, et al., 2002). In rural areas education and training play a pivotal role in helping smallholder farmers increase their productivity (IFAD, 2009). Skills development is particularly important to rural women, who have different training needs than men, since they often shoulder the responsibility of domestic work and childcare in addition to any income producing work (Hintermeister, 1984; International Labor Organization (ILO), 2012).

Information access and horticulture productivity

The key to overcoming gender disparity in accessing technology and tools, and promoting equal participation in production means is rooted in understanding how labor on farms is divided across gender lines (Katz, 2003). In rural Guatemala, there are specific gender ascribed norms for most tasks in crop production, as it is typically a family affair (Collet, Gale, & Walker, 2009). The woman's role in horticulture production is often in harvesting, while the man controls marketing and sales (United Stats Agency for International Development (USAID), 2012). While there are no explicit policies that bar women from accessing skill-based or vocational training, this discrepancy in production roles hinders equal participation. In a study of Kaqchikel women in the Western Highlands of Guatemala, many women stated that they simply did not know how to participate in the marketplace. Many women in this study said that this was considered the responsibility of their husbands or the male heads of the household. Studies estimate that when agricultural training sessions were offered in rural areas over 70 percent of those who attended were men (Hamilton, et al., 2002; Weibe, 2000*)*.

Gender disparities in training participation limits information available to women. Extension programs often assume that the information learned will be passed on to all members of the family. This is not always the case. In the long-term, failure to share information increases the gender inequalities in agriculture production. With training men adopted more technical production knowledge and skills, leading to an increase in their productivity and income. This is closely related to representation, as after training rural men's participation in cooperatives increased and women's participation remained stagnant. Subsequently, men were able to take greater control of the smallholder farms, while women's share of unpaid labor on these farms increased drastically (Hamilton & Fischer, 2003).

In Guatemala women are typically only engaging in labor related activities such as weeding, planting, and harvesting. Extension services target landowners, who are usually male. Women's concentration at early stages of the value chain and lack of land ownership preclude their participation in more advanced training offered by extension. Lack of training reduces women's employment opportunities in agriculture (Ashby, 1981).

In the past decade many projects have attempted to increase the number of training opportunities in areas with high concentrations of women. However, these projects acknowledged that women's access to extension services may have been constrained because most extension agents are men (World Bank, 2010b; Food and Agriculture Organization of the United Nations (FAO), 2011). Studies have shown that male extension agents connect less effectively with female farmers despite no explicit cultural restraints on interactions between men and women. Women's roles in production and the horticulture value chain because of ascribed gender responsibilities in farm production affect how male extension officers perceive female farmers. These ideas have encouraged men to attribute a lower level of importance to training that targets women (Ashby, 1981; Hamilton, et al., 2002; Weibe, 2000).

The need for training that targets women

Women in Guatemala face significant barriers in accessing relevant training. Obstacles include: low literacy levels, less property ownership, domestic obligations, and training that primarily targets men. The most marginalized among Guatemalan women are landless, female-headed, indigenous households. These households have the highest levels of poverty and face the greatest access issues to any type of agriculture training (United Nations Development Program (UNDP), 2011). Women have different needs and different variables affect their participation rates; studies show that addressing these challenges is important to increasing women’s involvement in training.

The rise of non-traditional agricultural exports in Guatemala has led to the increase of large corporations contracting with rural farmers. Companies tend to contract with men, in part because the companies will benefit from the unpaid labor of the man’s family. As a result, training done by these companies typically targets men. Subsequently, women often remain invisible and unrecognized in interventions that are aimed at upgrading producers in the value chain (Monu, 1988; Verhart & Pyburn, 2010).

Land tenure and inheritance

Guatemala ended its 36-year civil war with the 1996 Peace Accords. In its aftermath large percentages of the population were left displaced and unable to support themselves, exacerbating the already inequitable land distribution. Guatemala has the most inequitable land distribution in Central America as measured by its Gini coefficient for land distribution of 0.86 where 1.0 represents perfect inequality (Grobakken, 2005; FAO, 2004). The 1996 Peace Accords emphasized the need for land reform, noting the need to provide women with greater opportunities for land ownership. Minimal progress has been made in achieving land equality (Carter, Barham, & Mesbah, 1996).

Access to land for indigenous populations

The most vulnerable populations in terms of poverty, malnutrition, and stunting are those who live in the rural areas. In addition, these groups are predominantly indigenous and do not own land. Among the most vulnerable indigenous groups are: 1) Small-scale farmers in eastern transitional lands near the border with Honduras, 2) Small-scale farmers in northern lowlands and highlands (primarily in Alta Verapaz), 20 percent of whom are landless and the rest have land but no title, 3) Small-scale farmers in the western volcanic lands, transitional lands, and highlands, of whom 54 percent have little or no land (Hamilton et al., 2002; USAID, 2012). Not owning land is a major barrier for indigenous groups, as land ownership is both a signifier of wealth and indicates access to other resources that can increase horticultural productivity.

Inequitable land distribution can be seen in the distribution of arable farmland in Guatemala; an estimated two percent of the population controls roughly 70 percent of the country's usable farmland. This distribution, which reflects discrimination against women and certain ethnic groups, has intensified the economic polarization of Guatemalan society. Only about 24 percent of farmland is in the hands of indigenous people, despite the fact that the majority of indigenous people engage in some sort of agricultural activity and represent 40 percent of Guatemala's population. Many indigenous famers lack legal titles to the land they farm (UNDP, 2010a, UN Women and Health Program 2011).

Entry into modern production chains frequently requires land tenure, and the ability to make investments in infrastructure, such as: greenhouses, irrigation systems, and packing sheds necessary to deliver the quantity and quality of produce demanded by buyers. Land rights are inherently tied to accessing capital and credit, as proof of title deed is generally required to serve as collateral for accessing loans. Smallholder, indigenous farmers often lack resources to invest in the necessary farm equipment to compete in horticulture markets without credit (Hamilton & de Barrios, 2002; Katz 2003; Quisumbing, Brown, Feldstein, Haddad & Pena, 1995).

Those who own land in the rural areas typically contract with large-scale commercial businesses. Exports of non-traditional agricultural products, such as snow peas, green beans, and mini-vegetables grew by 541 percent between 1999 and 2008 in Guatemala (CIA, 2012). Contracting households are typically male-headed with higher than average income levels and larger household sizes. Commercial agricultural companies are interested in these households because the companies know that the households can deliver larger quantities of agricultural goods due to assistance from unpaid family labor. Not only are women less likely to own land, they are also less likely to receive contracts from these large-scale businesses which can be a beneficial source of revenue for households. Only six percent of female-headed households are contracted with commercial companies (Mehra & Rojas, 2008).

Access to land for women

There are no legal restrictions to women's ownership or access to land in Guatemala. However, only 27 percent of titles to landed property belong to women. This number is even lower for indigenous women among whom only six percent farm land to which they have a title. Fifty-eight percent of Guatemalan women are landless and typically work as hired labor. The small percentage of female landowners stems from strong socio-cultural and financial barriers (United Nations Development Programme (UNDP), 2010a; Montenegro, 2002).

The average landholding in rural areas of Guatemala is 0.7 hectares. When a household buys a plot of land—despite being jointly registered under the names of both spouses—women typically do not have control over what is produced on that land; their inclusion on the title does not translate into ownership in practice. In only 11 percent of cases where titles are registered to one individual is the woman's name given (Hamilton, 2002). It is difficult to ascertain if these women also have only tokenistic ownership of their land or if this registration indicates greater control for these women farmers. Indigenous populations in Guatemala are characterized as patriarchal with respect to landholding and land-use decision-making. This influences control of agricultural incomes and other economic resources (Katz, 1995). Despite contributing labor to the production process, women do not benefit as much as their male counterparts because women have little control over the money received from the production of horticultural goods (Hamilton, Asturias de Barrios, & Tevalán, 2001; Hamilton et al., 2002).

Land reform in Guatemala

While there is no explicit law prohibiting indigenous people in Guatemala from accessing land, attempts at land reform have been unsuccessful. During colonization indigenous farmers were relocated to the most unproductive farmlands, where they struggled to survive from subsistence farming. The 1952 Agrarian Reform law sought to redress this but resulted in a coup and the beginning of Guatemala's civil war. The civil war reinforced land inequality, as the best lands were awarded to military officers and rich landowners tied to the military regimes (Grobakken 2005; Melville & Melville 1971; Viscidi 2004;).

After the civil war ended hundreds of thousands of internally displaced people sought to return to land they had previously occupied without formal title, while others tried to acquire new land. The redistribution of land to these people and to the Mayan indigenous population was prioritized in the 1996 Peace Accords. However, attempts to implement these policies have remained stagnant (Katz, 2000; Viscidi, 2004). The role of land reform in initiating the civil war has contributed to a climate that is resistant to land reform (World Bank, 1995).

ACCESS TO CREDIT AND FINANCIAL SERVICES

Guatemala's financial sector

The Guatemalan financial system includes 18 banks and 14 informal financial institutions. Guatemala's central bank, Banco de Guatemala regulates banking institutions (Government of Guatemala, 2013). Guatemala's financial sector was only liberalized in the early nineties, which led to a massive increase of banks, foreign banks, and other financial institutions. Ten years after this liberalization, the banking system crashed because of volatility in coffee prices upon which the economy was heavily dependent. In the aftermath of this downturn, many Guatemalans were unable to pay back their loans, leading commercial banks to curtail lending (United Nations Environmental Program (UNEP), 2006). Subsequent international development aid to Guatemala prioritized supporting a new legal framework for banking, anti-money laundering, financial supervision, and central banking to meet international standards and strengthen the country's ability to withstand financial shocks (Morrison & Fay, 2002; United States Department of State, 2012 (USSD); World Bank: Project and Operations, 2013). Recently, the banking sector has remained fairly stable and the number of loans made available to the public is increasing rapidly.

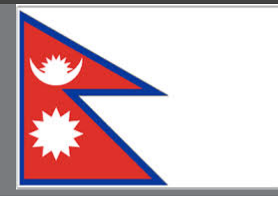
Rural financial access

Historically, loans were only made to fairly low-risk individuals in urban areas due to the instability of the financial sector. Offering loans and credit to rural areas, which host 54 percent of the country's population, was not a major priority for Guatemala's financial institutions (CIA, 2012; UNEP, 2006). In the past decade the Government of Guatemala has made efforts to expand credit access to rural populations, especially targeting the indigenous groups. One such investment was Banrural, an agrarian bank, which provides 94 percent of all loans given to rural dwellers. Banrural currently has over 200,000 clients, 60 percent of whom are indigenous. The bank is specifically designed to serve the rural demographic and is the only bank to target indigenous populations; its services are offered in 20 indigenous languages and the default interest rate is under 1.5 percent (Trivelli & Piselli, 2007; World Bank, 2008).

Women's access to credit

There is no legal restriction on women's access to bank loans in Guatemala. However, access to formal loans is limited for indigenous women. Banrural grants very few loans to women for agricultural activities and indigenous women are generally unable to obtain loans because they lack title deeds or other assets that could be used as collateral. Owning land is central to securing credit and the majority of women do not own land. These requirements leave individuals with low incomes and non-land assets with few opportunities for obtaining credit (Barham et al., 1996; Diagne, Zeller, & Sharma 2000; Mushinski, 1999).

Nepal



Nepal is landlocked in south Asia, nestled between India and China. Nepal's population is over 30 million; many Nepali men work abroad and send remittances back to their families. Over half of Nepal's population falls below the poverty line, living on less than two dollars per day. Agriculture comprises 38% of the GDP, and remittances contribute approximately 23%. Physical infrastructure and poor physical connectivity are major issues in Nepal. Nepal has the lowest road density in south Asia; communities in the hill areas must travel an average of four hours to reach the nearest road. Nepal has suffered two decades of political instability and paralysis since the outbreak of the civil war, ending with the peace agreements in 2006. There are laws advocating for women's status as equal members in society, with equal rights and responsibilities to men. Women's advocacy groups have actively petitioned for women's rights, but women still face many barriers in Nepal at large, and in horticulture production.

Key Findings

Nepal's Dalit communities are highly marginalized. Dalits are typically not allowed to enter public spaces such as temples, restaurants or other common areas. Dalit women face enormous obstacles, as they are discriminated against in society and within their own communities.

Nepal has a quota mandating that at least one third of government bodies are females. This quota emerged following pressure from women's advocacy groups. Although many government bodies have met this quota, elected women are not representative of the women of Nepal because their participation is often dependent on kinship to male politicians rather than skills or qualifications.

Nepali women constitute approximately 90 percent of the agriculture workforce. In most cases, their work is not considered as formal labor. Women work longer hours than men due to household and agricultural responsibilities but are offered poor extension services in comparison to their male counterparts. Extension services rarely cater to women. Because women have temporal and geographic limitations, they are often unable to access training that does not actively seek to include women.

Approximately 22 percent of the Nepali population is landless. Land inheritance laws discriminate against women, where a woman's inheritance is conditional to her age and marital status. Clear titles are often required to serve as collateral and acquire credit. Subsequently, women are often unable to access credit to improve their businesses, and are in perpetual poverty.

Adult women's literacy rates lag drastically behind that of men, at 48.3 percent and 73 percent respectively. Literacy and basic education are important building blocks for developing skills and accessing technology for enhancing horticulture production, such as learning specific practices, utilizing financial resources, and participating in markets. Educational disparities, specifically related to literacy, may also inhibit women's understanding of their legal rights.

Recommendations

Promote collaboration between various stakeholders such as female advocacy groups, government and international donors to encourage comprehensive programs that seek to address issues of women's representation across all relevant sectors.

Encourage women's participation in decision-making positions within committees, commissions, and political forums. Governments may need to provide women with resources and trainings to develop the skills required for becoming political candidates and leaders. Since political culture is strongly male dominated, political parties should promote female candidates. This can be done through funding candidates and women party members. Additionally parties can mandate party balance between genders and in party management and committees. Moreover, all candidates should be provided with training in gender related issues. Political parties should discuss how to create an enabling environment that promotes the participation of women.

Build support and capacity for female land ownership. Various stakeholders such as communities, female advocacy groups, and donors can collaborate to promote an environment that encourages land ownership by women. This will require collaboration at many levels, from holding community sessions to discuss the importance of women owning land for individuals and the community as a whole, to providing legal incentives, implementing laws, or enacting policies that facilitate land ownership for women. The current registration fee waiver for registering land in a woman's name is one such example. Similar legal incentives should be integrated into the legal system.

Offer training in financial literacy for all people in Nepal, especially women. Women have limited access to financial resources; informing women about minimum requirements, potential benefits, and how to utilize the legal system could increase their access to credit and enable the potential of women-led horticulture enterprises.

Identify opportunities to increase accessibility of financial services to women. Cooperatives and other informal institutions could decrease the threshold for women to borrow, especially on small loans. Financial institutions, community organizations, NGOs, or other stakeholders should provide education to facilitate the borrowing and repayment processes. Accepting moveable (i.e. non-land) forms of collateral would improve women's ability to borrow.

Provide extension services that actively target women and serve their unique training needs. Women in Nepal are restricted in terms of travel. Single-day training activities where educators come to farms or communities would minimize mobility barriers faced by Nepali women. Additionally, any technology provided should be simple and require minimal maintenance or repair. Training should include an emphasis on appropriate care and maintenance of any technologies introduced to minimize mobility or infrastructure access issues prevalent in Nepal.

Increase the number of female extension agents. There are cultural barriers that dictate interaction between men and women in Nepal. Additionally, extension workers often target landowners, who are often male and do not communicate the information with the rest of the household. Female extension officers could interact with women farmers more freely and ensure that women are getting the training support to improve their production and processing methods.

Female representation

Representation in the Dalit community

The Nepali population is a mosaic of diverse ethnic groups and caste systems. The country's social structure is highly influenced by Hindu principles. There are four main castes in Nepal: *Brahmans*—priests—who are at the top of the caste system, followed by *Kshatriya*—kings and warriors, then *Vaishya*—merchants, and finally *Sudra*—peasants and laborers. The other groups, which are socially excluded from the caste system, are known as Dalits or the untouchables. The Dalit community is estimated to be 13 percent of the population, though the true number is often believed to be higher (20 percent). Of all communities the Dalits are the most marginalized and face discrimination within their own communities. Discrimination against the Dalits includes enforced banishment from public spaces and no access to public services (World Bank & Department for International Development (DFID), 2006). In addition to being excluded from using communal water taps, Dalits are also barred from entering public spaces such as restaurants, temples, or taking part in cultural events (Dalit Welfare Organization (DWO), 2013).

Within Nepal, Dalit women suffer the repercussions of discrimination the most as they face exclusion and discrimination for both their gender within the country and their own communities, as well as marginalization as members of the Dalit caste. Despite an official government ban on discrimination in 1963, caste-based discrimination persists (World Bank & DFID, 2006).

Representation in government

In 1996 an insurgency led by Maoist extremists broke out in Nepal, leading to a decade long civil war between Maoists and the government. Due to the government's instability, King Gyanendra temporarily gained control over the government twice in 2002 and 2005 (BBC News, 2013). In 2006, after much negotiation between political factions, the comprehensive peace accords (CPA) were signed and a constituent assembly (CA) was created with the task of writing the country's new constitution (Jagaran Nepal, 2012). After repeated failures to draft a new constitution the CA was dissolved in 2012 and an interim government currently oversees Nepal (Central Intelligence Agency (CIA), 2013).

In the elections following the CPA, a committee tasked with drafting an interim constitution was formed (Falch, 2010). This committee initially had no female representatives but women's advocacy groups protested. Consequently, four women and one representative from the Dalit community were added to the six original male members of the committee. In response to public pressure from women's groups, the interim constitution includes a clause promoting affirmative action for female political representation. The interim constitution stipulates that at least one third of candidates in the constituent assembly and other government bodies must be women. This clause contributed to high participation (35 percent) of female candidates in the 2008 election (Falch, 2010).

Though the one-third quota has been met in some areas of government, such as Parliament, female representation in other governing institutions remains low. Women's presence in the political sphere does not guarantee effective representation. Political parties are male dominated and senior and high caste male leaders make most decisions. Women's political strength remains limited; in most cases women are politicians in title only—fulfilling quota requirements—and are not given opportunities to act or make decisions on behalf of their constituents. Additionally, women's opportunities to enter the political sphere typically depend on their kinship and loyalty to male politicians, not female candidates' relevant skills and performance. This selection process indicates that women elected to public office often do not capture the diversity of Nepali women with regards to caste, religion, and background. Political participation and success of female politicians are hindered by women's lower literacy rates, low levels of education, and lack of political experience (Falch, 2010).

Within the government women have formed alliances amongst themselves to overcome discrimination, strengthen their presence, and lobby for issues that are of importance for women. Women's political influences remain weak as male representatives fail to prioritize women's issues. Politicians in power, specifically male politicians, have little incentive to improve the status of women in either the political or social sphere (Falch, 2010).

Representation in employment

Of 11.8 million Nepali workers only two million are classified as paid employees. Women represent one quarter of paid employees and earn lower wages than their male counterparts. Men earn an average wage 1.7 times higher than women (Khare & Slany, 2011). Only 7.7 percent of women receive compensation equal to their male counterparts who perform the same tasks (International Labor Organization (ILO), 2012). There are more female workers than there are male because of high emigration for men who travel abroad to find work. In some regions of Nepal nearly 75 percent of families have one male member who has moved to another country to earn income (United Nations Education, Scientific, and Cultural Organization (UNESCO), 2011). In most cases male family members spend the majority of the year working in other countries. Remittances constitute 22 percent of the country's GDP (World Bank, 2012).

The agriculture sector is one of the largest employment sectors in the country, comprising 38 percent of Nepal's GDP. The number of women employed exceeds the number of men, especially in rural areas (Khare & Slany, 2011). Many duties performed by women are not recognized as formal economic activity, including weeding, harvesting, gardening, livestock and poultry production, and gathering fuel and water (Sustainable Development Department of the Food and Agriculture Organization of the United Nations (SDD FAO), 2013). Most of the agricultural sector is concentrated in the informal economy thus lacking many legal protections for formal employees, leaving the high number of women working in this sector vulnerable (Khare & Slany, 2011).

Representation in education

Article 17 of Nepal's interim constitution states that every community has the right to education in its own language and that there should be no costs to primary education (UNESCO, 2011).

Adult literacy rates for individuals over the age of 15 are 73 percent for men and 48.3 percent for women. This gap is narrowing among youth but disparity persists. In primary education the Gross Enrollment Rate (GER)[1] of boys was 123 percent in comparison to girls' 106 percent GER. As for secondary enrollment, GER was 48 percent for boys and 35 percent for girls. Tertiary GER was 8 percent compared to 2 percent for boys and girls, respectively (UNESCO United Nations Institute of Statistics (UNIS), 2012). Because of the way GER is calculated these statistics do not conclusively illustrate that female participation is lower; it is assumed that women's lower GER rates reflect lower retention rates of female students.

Dropout rates are often higher for girls as they get older and are able to perform household chores or work in the field. Additionally, many girls are married off in their adolescent years (Reynolds, 2011). Education is often not relevant to opportunities available to girls and often fails to equip them with appropriate skill sets. Physical risks such as walking to distant schools or harassment by teachers or students contribute to parents' reluctance to send daughters to school (Lone, 1996).

The Dalit community is heavily marginalized in the education sector, with literacy rates below the national average. In the more populous Terai region, Dalit literacy rates are one-third the rates of upper caste groups, at 21 percent and 74 percent, respectively. Additionally, Dalit children are less likely to have attended school, and those who do attend are more likely to drop out. The retention rate within the Dalit community is low, where 41 percent of grade one students do not reach grade five. Only two percent of teachers are Dalit. Women and girls in these communities are under dual burden of discrimination for their caste and their gender (DWO, 2013).

[1] GER is the number of pupils enrolled in a given level of education regardless of age expressed as a percentage of the population in the theoretical age group for that level of education. The GER may be greater than 100% when students younger or older than the official age for a given level of education are enrolled in that level." (UNESCO-UIS, 2012)

Skills-based training

Nepal has three major topographic features, which limit accessibility to services and markets. The southern region, the Terai, constitutes about 23 percent of Nepal's land and is in lower altitude areas. The Terai is the most densely populated and the primary region for agriculture. North of Terai is the hill regions, which comprise 42 percent of the country's land and consists of mountains, flatlands, valleys, and hills. These more remote areas still practice agriculture but do so on marginal lands and with restricted market access. The farthest north region is known as the Himalayan range, which has approximately 200 peaks, some of which are the world's highest ranges (Library of Congress, 2005).

Over 80 percent of the country's economically active population is engaged in agricultural activities of some sort; most activities are concentrated in the rural areas of Nepal. Approximately 90.5 percent of Nepali women are engaged in agriculture, compared to 74.9 percent of men (FAO, 1999). Women work longer hours than men, as they have both work in the fields and household responsibilities

(Sontheimer, Basnyat, & Mahrajan, 2013). Despite women's major contributions to agricultural productivity, they are offered lower quality extension services than those provided to their male counterparts (Sontheimer et al., 2013).

Many contributing factors limit women's access to extension services. Low numbers of female extension agents limit women's access because male extension workers usually do not understand gender-sensitive service delivery and are not trained to work with women. Cultural norms limit women in their mobility and freedom to move outside of their homes and communities. Women also have more responsibilities than men such as childcare and household chores. Finally, lower literacy rates make it difficult to circulate information about new technologies to women (FAO, 2010).

One government branch that supports local farmers is the District Agricultural Development and Livestock Offices. When created these offices had branches in most districts; however, restructuring of the Ministry of Agriculture centralized office locations restricted branch locations to district headquarters only. The offices have minimal resources and provide weak services; they are understaffed and do not remain in communities long enough to build effective relationships (Rao, 2010). There is limited data about extension training and other efforts to provide women with skills-based training, although several government agencies have recommended that this issue receive greater attention (FAO, 2010).

LAND TENURE AND INHERITANCE

Modern history of land tenure in Nepal

Nepal's modern history of land tenure is central to understanding women's barriers to land access and how these barriers impact horticulture. Nepal's land history has shown marginalized individuals' continuous struggle for their land rights. The Rana regime in the 19th century reinforced land inequality through prohibitive land taxes and other policies that kept land control in the hands of the elite (Adhikari, 2008). With the fall of the Ranas in the 1950s, attempts were made to reform land tenure. However, to date reform efforts have been met with very limited success.

A significant land rights movement rose after the fall of the Rana regime. The movement captured the ongoing tension between marginalized groups and the army, police, and landlords (Pathak, Sharma, & Uprety, 2009). Civil unrest spread across the country and protests were forcefully suppressed with significant casualties and minimal changes in land rights. To this day the majority of individuals who work the land do not own it (Dhakal, 2011).

Landless individuals

For the purpose of this paper, landlessness will be defined as "a situation, in which a person is dependent on agriculture but has no land in his/her own name or family member's name" (Adhikari, 2008). Almost 22 percent of the Nepali population is landless (Dhakal, 2011). In 2009 it was estimated that out of the population of six million Dalits, 15 percent of Dalits inhibiting the Western hills in Nepal and 44 percent of those in the Terai were landless

(Integrated Regional Information Networks (IRIN), 2010).

Women's landlessness deprives both women and their children from land security and the benefits of owning assets (Wily, Chapagain, & Sharma, 2008). Land access may offer a source of employment and can support livelihoods more directly through food production for home consumption. Since many livelihoods depend on secure land access, those without land are often marginalized in Nepali society. Individuals without land access may work for exploitative landlords as tenants or as bonded laborers, seeking to eliminate long-standing or inherited debt. Landless individuals often have little power or influence, and are forced to comply with powerful landlords (Community Self Reliance Centre (CSRC), 2009).

Although land codes provide landless tenant farmers with the right to purchase land they cultivate through cash and collateral, landowners may manipulate the system to their advantage and retain much of the land (IRIN, 2010). In most cases landowners do not live in the villages where they legally own land; these absentee landlords rarely offer appropriate management support to tenants but still earn profit from their land. In stark contrast, tenants who lack legal ownership rights to the land they farm, or in many cases are not even registered as tenant farmers, earn much less from the land they work, with estimates ranging from one-third to one-tenth of total earnings from the land (Integrated Regional Information Networks (IRIN), 2010). Poverty and exploitation of landless individuals often forces men to emigrate outside of Nepal to earn additional income to send to their families (Adhikari, 2008).

Women and land tenure

Traditionally women have owned little or no land; in rare circumstances of female landownership, legal records are not typically kept. In an effort to encourage female landownership, the government issued a waiver for registration fees if land is registered under a woman's name. As a result, land registered in a woman's name has increased markedly, doubling between 2007 and 2008. According to Nepal's 2011 Population Census, 14 percent of households have women with land registered in their names. Regions further west have lower rates of female landownership, with only four percent of households reporting women who have titles to land; whereas over 25 percent of households in the Terai report female ownership (Wily et al., 2008).

One study noted that community members generally agreed that there were benefits and security tied to female landownership as it gave women more of an equal stance and decreased their chances of being discriminated against. Despite community acknowledgement that female landownership provides potential benefits, it is often not viewed as crucial, particularly in communities with limited land resources. Landownership among women remains low. In the male-dominant culture of Nepal, women risk divorce if they ask to own their own land. Also, if a woman remarries after being widowed or divorced, her family forfeits access to all land that was in her name. In one survey regarding female landownership, women expressed the concern of working with government offices through difficult and time-consuming processes (Wily et al., 2009).

Laws for Land Tenure

A woman's inheritance rights depend on her marital status. An unmarried woman, who is at least 35 years of age, shares equal inheritance rights with her brothers to her paternal family property. However, if a woman marries she loses all inherited property and it is transferred to the most direct male descendant within her birth family (Adhikari, 2008; Asian Development Bank, 1999).

Married women have inheritance rights but these rights are typically conditional. Nepal's national code, amended in 1975, states that a woman has equal rights to her husband's property as their children (where female children inherit under the above-specified conditions). A woman has the right to claim her husband's ancestral property if she meets all of the following conditions: her husband is not alive, she was married to her husband for at least fifteen years, and she is at least thirty years of age. To retain property a woman must also remain loyal to her deceased husband's clan. If a woman were to remarry after being widowed, she loses her rights to property inherited from her deceased husband (Asian Development Bank, 1999).

Access to credit and financial services

The number of financial institutions in Nepal increased from two in 1980 to 264 in 2010. As of 2010, there are 87 development banks, 37 financial intermediary non-governmental organizations (NGO), 31 commercial banks, 21 microfinance development banks, 16 savings and cooperative and hundreds of other financially-related cooperatives (Nepal Rastra Bank, 2011). Only 26 percent of the country's population uses banks, 18 percent of households use an intermediary NGO and four percent utilize microfinance (Ferrari, Jaffrin, & Shrestha, 2007).

In the hill regions around 11 percent of the population has access to formal savings and other financial services, compared to the Terai, where 90 percent of the population has access to such services (Rao, 2010). Commercial banks withdrew from the hill areas during the civil war and have not returned to the region since the signing of the CPA, meaning farmers must ask neighbors, friends, or family for loans. This type of lending is usually accompanied by high interest rates. Some lenders prefer to delay repayment to maximize interest fees (Rao, 2010).

Government and central bank efforts

Due to Nepal's diverse topography, mountainous and hill areas are usually less productive agriculturally because markets are more difficult to access from these areas. In an effort to improve access to financial services in the hill areas, the government of Nepal has implemented two programs. The first is lending through the Agricultural Development Bank Limited (ADBL) and Regional Rural Development Banks (RRDB). The ADBL was formed in 1968 with the purpose of providing credit to individuals involved in agricultural activities. The bank has over 400 branches, including offices in the country's most rural areas. However, government affiliation with the ADBL has hindered its success. During and after the civil war and subsequent corruption, institutions were suspected of buying political votes with funding for ADBL and RRDB branches. Many individuals felt that the financial support offered through these institutions was deserved and that they should not have to repay the loans. Given the failure of government-run lending institutions in these areas, loans have since been privatized through the Small Farmers Cooperatives Limited (Rao, 2010).

The second program targeted at expanding financial access is Deprived Sector Lending; this requires a specific share of a bank's loan portfolio be allotted to the country's underserved populations. This program has been successful in vitalizing the microfinance sector. However, loan ceilings limit the maximum loan amount at levels that are often too small to meet the needs of rural farmers (Rao, 2010).

Cooperatives

There are roughly 2,300 financial cooperatives registered with Nepal's Rastra Bank and tens of thousands of informal cooperatives operating in Nepal. Cooperative members contribute a given amount of money to the cooperative on a monthly basis and are eligible for specific loans based on these contributions. Farmers benefit from cooperatives in comparison to other financial institutions (both formal and informal) because cooperatives cost less, are taxed less, and have lower interest rates (Rao, 2010). Given their limited resources, cooperative members must determine which group member receives the few funds available. Cooperatives often lack adequate management skills, governance, and monitoring. Entrepreneurial and politically influential families often run cooperatives, which does not allow for equal participation of all. Finally, cooperatives typically fail to finance poor farmers, as financial requirements for participation are still too high, even at lowered rates for cooperatives (Rao, 2010).

Microfinance

Despite the government's efforts to improve access to financial institutions, the lack of physical infrastructure remains a barrier to access. Approximately 51 percent of households are dependent on informal financial access, an increase of approximately 10 percent between 1995 and 2010. Nonetheless, borrowing from formal institutions increased from 16 percent in 1995 to 20 percent in 2010. In 2007 the government of Nepal adopted a microfinance strategy for poverty reduction, seeking to promote growth and expansion of microfinance institutions (MFIs) to rural areas (Nepal Rastra Bank, 2011).

Access to credit and land tenure

When women are unable to access the credit they need to start businesses and earn livelihoods, they are pushed into poverty, increasing their need for external support but reducing the likelihood and eligibility that they will access these services. Women's access to credit in both formal and informal institutions is strictly limited. To guarantee repayment, formal institutions typically lend only to individuals who can provide collateral. Moneylenders in villages, and other informal institutions, charge high interest rates and can acquire the debtor's property in the case of no repayment. It is rare to find a lender that is willing to lend to individuals with minimal resources (Asian Development Bank, 1999).

It is particularly difficult for women to access credit from formal institutions given the absence of physical infrastructure, combined with restrictive cultural norms that discourage women traveling or neglecting household and field duties. Lenders may take advantage of women who are less informed about their legal rights (Asian Development Bank, 1999). According to a study conducted by Nepal’s Rastra Bank in 1991, approximately 35 percent of sampled female-headed households borrowed from informal institutions and 15.4 percent borrowed from formal institutions (Asian Development Bank, 1999).

Tanzania

Tanzania, located in eastern Africa, boasts more than 1,400 km of coastline on the Indian Ocean and shares borders with Burundi, the Democratic Republic of the Congo, Kenya, Malawi, Mozambique, Rwanda, Uganda, and Zambia. The country is rich in natural resources, including tin, phosphates, iron ore, coal, diamonds, and gold. Despite these endowments, Tanzania remains a low-income country and ranked 152 out of 186 in the 2012 Human Development Index. The country's population is estimated at close to 48 million, of which 73% inhabit rural areas. Many of these rural residents depend on agriculture. While agriculture contributes about 27% of the country's GDP, the sector absorbs nearly 75% of Tanzania's labor force. Women's rights are enshrined in the Constitution and a number of key statutes, but cultural norms and rules in many areas of the country limit women's access to political and social capital and permit continued discrimination. Tanzania's horticulture sector is growing, but the country's potential for producing horticulture crops has not been fully realized. Barriers to progress include insufficient land, inadequate training, poor infrastructure, inadequate processing capacity, and lingering regulatory challenges that negatively affect the country's business climate.

Key Findings

Tanzania has made considerable progress in eliminating discriminatory language from national statute and other legal documents, but local customary laws and long-standing cultural practices may prevent women from obtaining their full legal rights.

Few women are directly elected to government offices in Tanzania, but their participation in both national and local governing bodies is ensured through quotas.

Two major land bill passed in 1999 affirmed women's rights to own and control land. However, in most cases the legal burden is on women to challenge discriminatory practices. Limited awareness of the law, lack of access to legal services, and cultural stigma contribute to an environment in which these customs are rarely questioned formally.

Many rural communities in Tanzania are patrilineal with customary or Islamic laws that limit the amount of land inherited by women or preclude women from inheriting land altogether.

Without land assets, women may find it difficult to obtain credit from formal institutions. Financial services also may be difficult to access in rural communities.

Tanzania has sought to engage more women in extension services by increasing the number of female extension officers in recent decades.

Recommendations

Expand Farmer Field Schools (FFS) in Tanzania. The FFS model has succeeded in drawing participants from low- and middle-income populations. The FFS approach seeks to capitalize on local farmer knowledge and expertise by facilitating group-based learning and sharing. The FFS model can be a cost-effective method of extending resources and information to more remote areas and encourage community-supported networks and ongoing collaboration. In addition, the less formal nature of FFS education may make the training method more accessible to producers with low levels of education. On tactic to increasing women's participation in FFS in Tanzania is to ensure that meetings, which include farmers and facilitators and often occur weekly, are held at times when women can play an active role.

Tap Tanzania's existing extension service to provide education to women. Tanzania's formal extension service continues to serve an important role in providing instruction and technical assistance to the country's farmers. The Government of Tanzania recognized the need for more female extension officers and has sought to increase the number of women employed by the service. HortCRSP should look for ways to work with the Government of Tanzania to develop metrics that reflect the goals of extension services and reduce reliance on performance contracts that may discourage extension officers from engaging with underserved populations.

Harness the power of Tanzania's civil society organizations engaged in the policy realm. Where HortCRSP is looking to accomplish objectives that advance Tanzanian women, working with active local groups may be advantageous.

Find ways to strengthen and grow women's cooperatives and farmers' organizations (FOs) to extend support to rural women. Cooperatives and FOs can facilitate skills-based training, identify markets, aggregate product, and provide both social and economic support. Connecting women producers through these groups and working to develop strong organizational management in these organizations can offer longer-term assurances that the gains in horticultural development will sustain.

Generate greater awareness about the statutory rights afforded to women and extend legal services that provide women an opportunity to challenge gender-based discrimination. One mechanism for achieving this goal, particularly among rural populations is through mobile legal clinics that can provide information about women's statutory rights. In Tanzania, the Women's Legal Aid Centre provides these services. The Tanzania Women's Lawyer's Association may be another strong partner in these efforts.

Offer leadership training to women representatives in local governing bodies. Three village-level governance bodies are responsible for land management, including land adjudication. Established quotas ensure that women comprise a minimum fraction of committee and council membership. Outreach to women who fill these positions to understand their level of participation and to convey the specific needs of women actively engaged in horticulture, could help inform future deliberations by these decision-making bodies. If women do not take an active role, leadership training might embolden them to engage more fully in the councils' work.

FEMALE REPRESENTATION

While the Government of Tanzania has made attempts to close the gender gap in several sectors, women remain a marginalized population in the country. Tanzania boasts a large number of distinct ethnic groups, often with unique customary practices that may influence women's participation in the social and political realm. Roughly 80 percent of these groups base inheritance and other rules on a patrilineal system. This often limits the power of women by tying their security to a husband, father, or male child (Tsikata, 2003). Women are more likely to live in rural areas where resources may be limited. These factors may constrain Tanzanian women's access to political and social capital and limit their representation in the country's economy, government, and education system.

Representation in government

The Government of the United Republic of Tanzania is organized as a multiparty parliamentary democracy. Its legislative branch is unicameral, consisting of a single National Assembly with both elected and appointed members. The legal system is guided by the Constitution, which was formally adopted in 1977. Despite a Constitutional prohibition on gender-based discrimination, some sources suggest that local customary laws that afford a legal basis for discrimination against women and girls are often given deference, particularly in rural areas (Ellis, A., Blackden, M., Cutura, J., MacCulloch, F., & Seebens, H., 2007).

Tanzania's electoral system relies on a "First-Past-the-Post" majoritarian system, eliminating the need for run-off elections by allowing the candidate who receives the largest vote tally to claim victory regardless of whether that number represents a majority of the electorate (United Nations Development Programme (UNDP), 2010b). The UNDP suggests that this system hurts female candidates' chances of being elected since parties have incentive to nominate candidates with broad appeal, which frequently excludes women. Over time this system encourages the emergence of two dominant political parties, limiting diversity.

The October 2010 election yielded 20 directly elected female members of parliament, or roughly 8.3 percent, representing a slight increase over 2005 when 17 women were elected. To address low numbers of directly elected women, Tanzania's Constitution provides reserved seats to ensure that women make up at least 30 percent of membership in the National Assembly. These special parliamentary seats are allocated to political parties who garner at least five percent of the vote (UNDP, 2010b). Today women make up 36 percent of Tanzania's National Assembly (International IDEA, Inter-Parliamentary Union and Stockholm University, 2011).

Tanzania also has established quotas for female representation in local government. Two 1999 land reform bills required that a minimum percentage of women make up the membership of three governing bodies with responsibilities for local land decisions. While quota provisions that apply to Village Councils, Land Adjudication Committees, and Village Land Councils demonstrate the Government of Tanzania's interest in addressing gender inequality in representation, female membership does not necessarily mean that these bodies effectively address gender discrimination (Carpano, 2010). As critics point out, membership numbers and percentages do not connote full and active participation by women (Carpano, 2010).

Representation in cooperatives and associations

Tanzania's Cooperative Development Policy, passed in 2002, notes the potential for cooperatives to advance economic opportunities for vulnerable populations. The policy also indicates that the Government of Tanzania will encourage cooperatives to promote women's membership and advocate for women to occupy cooperative leadership roles, as well as for an active role for women in cooperative education, training, and evaluation (Majurin, 2012). The Cooperative Societies Act of 2003 explicitly prohibits cooperatives from discriminating on the basis of gender (United Republic of Tanzania (URT), 2003).

National cooperative membership data for Tanzania are currently unavailable. A 2010 ILO survey in four of Tanzania's regions estimated women's share of primary cooperative membership was 20 percent; however, membership varied dramatically across the four sampled regions. Women tend to be better represented in cooperatives focused on the production of non-cash crops, specifically fruits, spices, and dairy (Maghimbi, 2010; Majurin, 2012). Women-centered cooperatives are extremely rare. A survey of five regions revealed only four percent of primary cooperatives and seven percent of financial cooperatives are comprised exclusively of women (Majurin, 2012).

A growing number of civil society organizations in distinct fields aim to advance the situation of women in Tanzania. Some key organizations, including the Federation of Associations of Women Entrepreneurs in Tanzania, the Tanzania Women's Chamber of Commerce, the Tanzania Association of Women Leaders in Agriculture and Environment, among other active groups, have had a growing role in shaping public policy. The Tanzania Women Lawyers' Association and allied groups influenced the drafting of major land reform bills in the late 1990s (Ellis, et. al., 2007). More recently, the Tanzania Gender Networking Program (TGNP) has successfully lobbied the Government of Tanzania for more gender-sensitive budgeting.

Representation in the economy

Women in Tanzania are nearly as likely as men to participate in the economy and comprise just over 50 percent of the country's labor force. However, women are more likely than men to be engaged in employment considered to be vulnerable, nearly 93 percent compared to 89 percent. Women are less likely than men to benefit from salaried employment or earn wages (World Bank, 2012c). In 2006 just over 30 percent of firms reported having female participation in ownership (World Bank, 2012c). These statistics illustrate the relatively low economic status of many Tanzanian women.

Representation in education

Tanzania has made significant progress in boosting the number of girls enrolled in both primary and secondary education. In recent years, even the gap between women and men attending institutions of higher education has narrowed considerably with a ratio of female to male enrollment in tertiary education of more than 0.82 (World Bank, 2012c). While these gains are important for the next generation of Tanzanian women, adult females in the country still lag behind their male counterparts when it comes to literacy. In 2010 over 79 percent of adult males in Tanzania were literate, while less than 67.5 percent of women achieved the same proficiency (World Bank, 2012c). Low levels of literacy and numeracy can disadvantage women, often preventing their participation in the formal labor market, but also may contribute to a lack of knowledge about their rights.

SKILLS-BASED TRAINING

Historically, most agricultural extension services in Tanzania have been administered through the Ministry of Agriculture Food Security and Cooperatives. The country's extension system includes both divisional extension officers and village extension officers. Donor funding is used to help support these public extension services (African Development Bank Operations Evaluation Department, 2004). While government programs are still dominant, new efforts led by agribusiness firms and non-governmental organizations have emerged to provide technical assistance to farmers (Rutatora & Mattee, 2001).

Training and technology access issues

Information on access to agricultural extension services in Tanzania is limited. According to Tanzania's National Sample Census of Agriculture, an estimated 67 percent of households received information or assistance from extension. However, the government document acknowledges that disparities in access may occur based on geographic location (URT, 2012). An independent 2002 survey found only one percent of respondents in a particular study area had taken advantage of extension services, while none of the women interviewed reported access to extension (Lyimo-Macha & Mdoe, 2002). Access challenges facing women may be more pronounced because women in Tanzania are concentrated in rural areas. These remote regions are particularly dependent on government-funded extension officers for any technical guidance and assistance in agricultural production. Evidence collected by researchers suggested that male extension officers, who dominated the profession until the late 1990s, rarely visited women. Male extension officers may face religious and cultural barriers to communicating effectively with women (Otsyina & Rosenber, 1999). In addition, where knowledge and training were shared with men, the information was not always transmitted to wives and other females in the household. Some research indicates that women in Tanzania prefer female extension officers (Due & Temu, 1997).

Studies have shown that farmers in Tanzania value extension services. Given the critical role women play in agricultural production in Tanzania – frequently shouldering the burden of seeding, weeding, harvesting, and other labor intensive jobs – many experts have concluded that additional female extension officers would be a worthwhile investment. Another challenge that may prevent women from benefitting from extension services is illiteracy (World Bank, 2012c).

Overcoming access issues

A variety of mission-driven NGOs in Tanzania target women and other vulnerable groups inhabiting rural areas. Given their location and experience, these organizations may be uniquely suited to facilitate women's access to extension services (Rutatora & Mattee, 2001). These organizations often lack the field staff to be spread broadly across a geographic region. In addition, the funding available for NGO-led extension work may be limited or intermittent. Farmers' organizations offer a more informal means of disseminating information and technology to food producers in Tanzania (Wennink & Heemskerk, 2006). Locally-based initiatives, such as farmer extension groups and farmer field schools, have a history of working with Tanzania's seven Zonal Agricultural Research and Development Institutes. Farmer Field Schools (FFS) in Tanzania have succeeded in drawing male and female participants from low- and middle-income populations (Davis, Nkonya, Kato, Mekonnen, Odendo, Miiro, & Nkuba, 2010).

LAND TENURE AND INHERITANCE

Approximately 98 percent of economically active rural women are engaged in agriculture (Ellis, et. al., 2007). According to the Census of Agriculture for 2003 to 2004, women made up only about 19.7 percent of landholders. Even where women have land access, lack of ownership, or insecurity of tenure can prevent women from investing in improvements that might increase its productivity (Ellis, et. al., 2007). Without titles to land, women may be unable to access credit to help pay for seed, inputs, transportation, and other production costs.

The legal right for women to own land in Tanzania is enshrined in a number of laws and legal documents. Tanzania's Constitution states that women may possess, own, and dispose of lawfully obtained property. Despite this provision, land tenure is a complicated and controversial issue in Tanzania, reflecting a tumultuous history of land policy and the country's cultural diversity. While land reform efforts granted women additional rights with respect to land control and inheritance, the implementation of these laws has not had the effect that advocates of greater gender equality had hoped (World Resources Institute (WRI), 2011).

A history of land rights and tenure in Tanzania

In pre-colonial times, Tanzania's land administration was generally left to individual clans and tribes (Pedersen, 2012). Most ethnic groups in Tanzania organized around patrilineal systems that gave property inheritance rights to male heirs. Under both German and British colonial rule, plantation-style, export-driven agriculture was favored; many indigenous and native Tanzanians lost control of land to foreigners due to their inability to prove ownership claims (Tsikata, 2003). The effect of these policies was to concentrate property ownership and increase the power of a small group of wealthy elite (Tsikata, 2003).

Following independence control of the country's land remained vested with the state, but Tanzania's government sought to restore greater equity in land ownership. Villagization, the rural development policy pursued during this period, involved large-scale resettlement of rural Tanzanians with the intent to facilitate collective agriculture (Peterman, 2011). Despite an underlying commitment to equality, land policies passed in 1975 effectively reverted back to customary practice in many aspects of land management that disadvantaged women. For instance, the policies conferred administration of land on the head of household, a role traditionally occupied by men. Thus, the policies during this period did little to increase land security for women and other vulnerable groups (Yngstrom, 2002). In the late 1980s Tanzania underwent significant political and economic change. An effort to liberalize the country's economy, challenges in existing policy, and a growing civil society movement spurred the country's massive land reform effort (World Resources Institute (WRI), 2011).

Land reform in Tanzania

Tanzania's land reform development began to take shape in the early 1990s when the Presidential Commission of Inquiry into Land Affairs issued its recommendations (Manji, 1998). However, the Commission's final report examined only women's rights in the context of inheritance and land succession and did not address other areas of gender discrimination (Tsikata, 2003). A few years later the country produced a National Land Policy (NLP). While the policy acknowledged the gender discrimination common in customary land allocation practices, it maintained that custom and tradition would continue to govern inheritance of clan land rather than a system that would allow more equitable access. Critics identified that the customary system had created conditions where male control was dominant and many women struggled to gain claim to land (Tsikata, 2003).

After the NLP was adopted, a draft land bill became public that still failed to address gender concerns and local advocacy groups mobilized to influence the policy formation process. The Tanzania Women Lawyers Association, one of the leading organizations to engage in the reform process, spurred formation of a Gender Land Task Force (GLTF) in 1997. The GLTF sought changes to the draft legislation but also worked to increase awareness of the land reform efforts in communities around the country (WRI, 2011). A position paper issued by GLTF made recommendations with respect to customary law, titling and registration, representation, and youth. Specifically, the group believed the government's continued commitment to customary law was unconstitutional because it infringed on women's rights. An estimated 80 percent of Tanzania's rural communities are patrilineal, with customary laws that often preclude women from inheriting family land or prevent them from passing land to their children (Tsikata, 2003).

Women and Access to Land

Two policies passed in Tanzania in 1999, the Land Act (No. 4) and the Village Land Act (No. 5), were heralded as among the most progressive in Africa. The Land Act explicitly affirms the protection of women's land rights as well as the principle of spousal co-ownership of family lands. In addition, the law provides for women representation in dispute settlement and land administration institutions to help ensure fair resolutions on land issues affecting women (Ellis, et. al, 2007). Advocates for women and other traditionally disadvantaged populations welcomed these changes, but some remained concerned that failure to amend existing customary laws would place the legal burden on women to challenge discriminatory practices.

Indeed, contradictory provisions remain formally codified. Most notably, the Local Customary Law (Declaration) (No. 4) Order issued in 1963 codified customary law that delivered inequitable treatment in property inheritance (Manji, 1998). Reflecting the practice of many patrilineal communities, the customary law prevents the inheritance of clan land by widowed or divorced women and girls. While the policies set forth in the national Land Act trump other rules, in practice, implementation varies widely across regions, ethnic groups, and communities. Inheritance is a particularly complicated legal issue because the system gives standing to statutory (which includes different policies pertaining to different ethnic groups), customary, and Islamic law (Leavens & Anderson, 2011).

Under the Law of Marriage, courts are to consider the local customs of the spouses' communities of origin (Ellis, et. al., 2007). Customary laws in many areas of Tanzania limit women's land inheritance rights to prevent land from leaving control of the clan. In divorce cases courts also may divide assets according to contributions to the marriage (Leavens & Anderson, 2011). Where patrilineal customs are part of the legal deliberation and women's contributions frequently comprise unpaid, household labor, the result is often discrimination against women. As part of the 2007/2008 National Sample Census of Agriculture, agriculture households were asked if women in the household owned or had any customary right to land. Approximately 74 percent of respondents from households in Mainland Tanzania answered "no" (URT, 2012).

Ultimately, while the land reforms specify that the courts must give preference to state law over any customary or Islamic law that may result in less equitable land rights, this is not always done in practice. For instance, the Land Acts allow women to register land in their own names and stipulate that matrimonial property be registered to both spouses. Lack of awareness and limited literacy in rural Tanzania may prevent women from registering their vested land interests. In some communities, such registration may be stigmatized as it contradicts socio-cultural norms (Tsikata, 2003).

Many women in Tanzania are unaware of their land rights, presenting a persistent challenge to achieving greater equity in land ownership. Even where awareness exists, access to legal representation to challenge unfair treatment may not. Though examples of women successfully defending right to property in a court may suggest attitudes are shifting, to date, these cases are limited in number (*Bernado Ephrahim v. Holaria Pastory*; *Hamida Abdul v. Ramadhani Mwakaje*) (Ellis, et. al. 2007). Several international NGOs have sought to provide legal assistance to women in this area.

ACCESS TO CREDIT AND FINANCIAL SERVICES

Access to credit and financial services as a barrier to horticultural development

Lack of credit access is often cited as a barrier inhibiting the success of micro, small, and medium enterprises (MSMEs) in many developing countries. This includes operations selling horticultural products in Tanzania. The Horticultural Development Council of Tanzania (2010) cites limited access to credit as a key constraint facing the agricultural sector. Without access to credit it is difficult for farmers to have access to the capital needed for production. These capital constraints may prevent producers from investing in seed stock, fertilizer, disease treatments, modest processing equipment, packaging, construction of storage facilities, and transportation to market (Horticultural Development Council of Tanzania (HODECT), 2010). Improving access to credit has been recognized as a driving force behind land reforms in Tanzania and other sub-Saharan African countries, as formal land rights are often a prerequisite to securing loans from financial institutions (Manji, 2010).

Tanzania's financial sector

Tanzania's financial services sector consists of commercial banks, financial non-government organizations, community banks, and microfinance institutions. Despite growth in both the number of institutions providing financial services and in total assets held by these operations, boosting financial inclusion remains a challenge in Tanzania. As of 2011 the country had 45 commercial banks with a combined total of 517 branches (Serengeti Advisers, 2012). However, only 17 percent of Tanzania's residents take advantage of these formal financial institutions (World Bank, 2012c).

The rural/urban divide

Women in Tanzania are more likely than men to be employed in agriculture and less likely to live in an urban setting (World Bank, 2012c). As a result, the disparity between the country's rural and urban populations in accessing credit may have significant implications for women. Tanzania's urban dwellers are more than twice as likely to bank in the formal system as rural residents (World Bank, 2012c). This suggests that geographic location may be one of the greatest obstacles to accessing the benefits of financial services. For Tanzania, tackling this inequality represents a particularly difficult challenge since an estimated 73 percent of the population resides in rural areas. Similarly, Tanzanians who earn income from agriculture are among the most financially isolated in the country (FinScope, 2009).

In recent years Tanzania's government has sought to extend credit access to the country's underserved rural and agrarian populations. Initiatives such as the Rural Financial Services Program and the Agricultural Marketing Systems Development Program, have worked to multiply and strengthen the available grassroots microfinance institutions and credit organizations that provide support for agricultural marketing activities (International Fund for Agricultural Development (IFAD), 2011). These programs are thought have achieved some progress but have fallen short of established targets in the area of institutional development. They have also struggled to cover transaction costs. Evaluators suggest that the targeted grassroots microfinance organizations had weaker institutional capacity than was assumed during program planning and design. The high service delivery costs associated with extending credit access to the beneficiary populations, including women, proved difficult to contain and could jeopardize the potential to scale up these programs.

Women's access to financial services

Women in Tanzania are less likely to hold an account with a formal financial institution than men, with rates of roughly 14 percent and 21 percent, respectively (World Bank, 2012c). In addition, according to a countrywide survey, Tanzanians report economic and price barriers as the primary reasons for not having bank accounts. The second most cited barrier to access was lack of knowledge about banking options (FinScope, 2009). This survey and responses from a 2009 Mbozi District study indicate that careful risk analysis may cause rural residents, particularly smallholder farmers, to avoid applying for loans from formal institutions (Sanga, 2009). These farmers may fear acquiring debt or feel unprepared to appropriately manage the risk inherent in crop production.

Other barriers that disproportionately impact women include: lack of appropriate documentation (e.g. identification cards), minimum deposit requirements, and large banks' preference to serve higher-income customers (Losindilo, Mussa, & Akarro, 2010; Manji, 2010). Tanzanian women are also often relegated to societal roles that provide no compensation but demand great labor and time, such as household chores and childcare. Recent data suggests that women are less likely than men to be paid for their work. When asked in the 2010 Tanzania Demographic and Health Survey (TDHS), 53 percent of women reported being unpaid for employment in the previous 12 months compared to 28 percent of male respondents. In addition, female-headed households, which comprise approximately 25 percent of total households, are typically poorer than those headed by men. This situation puts many Tanzanian women at a distinct economic disadvantage and exacerbates the challenge of securing credit (TDHS, 2010).

Access to credit is inextricably linked to formal land rights. Historically, banks have accepted land exclusively as collateral. International institutions actively encouraged the formalization of Tanzanian land rights in an effort to stimulate economic growth in the country (Manji, 2010). Research shows that plots of land owned by women in Tanzania are smaller than those owned by men, an average of 1.86 and 2.73 hectares, respectively (Cotula, 2006). As a result of land reform statutes, spousal ownership of family land has become increasingly recognized. However, women remain more likely to have movable assets rather than fixed assets that can be leveraged as collateral. As a result of this, women may have insufficient collateral to offer to lenders and may be denied credit access.

In 2004 an amendment to the Land Act afforded Tanzanian women the right to mortgage land in order to gain access to bank loans. Previously, a national women's development fund was one of the few gateways to commercial loans available to women in Tanzania. In many areas customary laws surrounding inheritance and land tenure prevent women from achieving access to credit (Ellis, et. al, 2007). The Government of Tanzania undertook a comprehensive review and reform effort focused on the country's leasing laws in 2007 and 2008. New regulations based on these statutes were drafted in 2011. To date, research on the impact of these changes is limited.

Reports indicate that some commercial banks opposed an effort to further equal treatment for women in land ownership during the drafting of the 1999 Land Act (Manji, 2010). These banks opposed a provision that would allow courts to renegotiate the terms of a mortgage if it found the terms to discriminate on the basis of gender in a way that disadvantaged the borrower. This example illustrates that poverty alleviation strategies aimed at strengthening the financial sector should be approached with an appropriate degree of caution. Enhancing the power of financial institutions, particularly large commercial banks, may not benefit women and other disadvantaged populations (Manji, 2010).

To address barriers that women face in accessing financial services, the country opened Africa's first women's bank in Dar es Salaam in 2009. The Tanzania Women's Bank requires only an identification card or passport to open a bank account. Although the bank has struggled to obtain the capital base necessary to expand into more rural areas, the bank's rate of growth suggests there are reasons to be optimistic about the institution's future (Global Power WOMEN Network African, 2012).

Microfinance

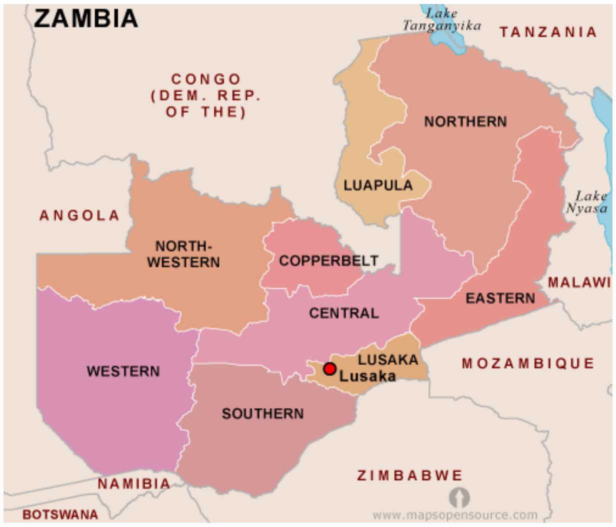
Microfinance initiatives have sought to bridge a number of gaps listed previously. They have been able to do so by operating at the community level and seeking to meet the needs of groups historically unable to patronize commercial banks. Among these groups are women, rural residents, and the poor. Unfortunately, the impact of microfinance can be difficult to measure, since these small lending groups may suffer selection bias. In addition, above average default rates force some microfinance institutions to charge high interest for lenders who may not be able to afford it and still struggle to realize profits. Furthermore, these loans may be used to fund basic consumption rather than boost productivity in horticulture or achieve market access (Manji, 2010).

In Tanzania microcredit lending organizations take a few forms. Savings and Credit Cooperative Societies (SACCOs) occupy a semi-formal space since these organizations register with the government. Tanzania has witnessed tremendous growth in the number of SACCOs in recent years but these organizations play only a small role in improving financial inclusion (FinScope, 2009). While serving almost exclusively rural areas, reviews of these institutions have been mixed. Poor management, often combined with low loan repayment rates, has led to the collapse of some of these organizations. This may be because Tanzania has many more SACCOs with varying levels of quality and generally lower capacity.

Some experts have suggested that traditionally financially excluded populations would be better served by devoting more resources to building the organizational strength of SACCOs and establishing ties between SACCOs and formal financial institutions (The Citizen Reporter, Tanzania, 2010). Still, these organizations may find it difficult to manage risk and cover transaction costs without charging the high interest rates that keep their lending services out of reach for the most resource constrained. Others urge caution when attempting to use microfinance as a poverty alleviation strategy, noting that it can be easy for poor women and other vulnerable populations to fall deeply into debt. With these challenges in mind, some groups have supported the establishment of even more informal Savings and Credit Associations and savings clubs to extend access to credit.

Financial regulations in Tanzania can limit the ability of commercial banks, which have more capacity, to serve women through microfinance. The Bank of Tanzania's guidelines state that an unsecured loan to a single borrower may not exceed five percent of a financial institution's core capital. While this rule does not apply to microfinance companies or financial cooperatives, it restricts commercial banks from widely offering microfinance loans, which are generally unsecured (Ellis, et. al., 2007). Overall, microfinance institutions hold promise for extending credit access to women. However, many organizations offering microcredit products would benefit from capacity building and institutional development.

Zambia



Zambia is a sparsely populated, land-locked country in Southern Africa, sharing borders with Angola, Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania, and Zimbabwe. Agriculture comprises 21% of the country's GDP and employs 85% of the labor force. As of 2006, 64% of the population lived below the poverty line, with rates higher in rural areas where there is poor infrastructure and limited access to services and amenities available in urban areas (Central Intelligence Agency World Fact Book; 2013). Although the constitution prohibits gender-based discrimination, women in Zambia are often discriminated against, particularly in rural areas where customary law and traditions prevail. Gender-based violence is prevalent in Zambia. Women face many barriers to actualizing the potential benefits of horticulture in Zambia, including health circumstances, educational and economic disparities, poor infrastructure, land tenure regulations, legal complications, and cultural norms and attitudes.

Key Findings

Horticulture is widespread in Zambia, with many smallholder farms producing fresh fruits and vegetables. While some of this produce is consumed at the household-level, much is sold in open-air markets. There are some connections to high-value export markets, but these are often not accessible to rural smallholders.

Under customary law and land tenure, women typically do not own land, but rather access it through their husbands, sons, or birth families. In the case of death or divorce, women are often left landless. Customary inheritance and land tenure practices often rely on socio-cultural norms that discriminate against women.

Extension services targeting landowners work primarily with men, meaning women are often excluded from these educational opportunities. Access to training and technology are further limited in rural areas with poor infrastructure and limited market access. When combined, these factors exclude women from receiving extension training.

There are few female extension workers in Zambia. Rural women, who may be incentivized to serve other rural women, face the greatest educational and financial barriers to accessing vocational training to become extension workers.

Women are overrepresented in vulnerable employment sectors in horticulture as informal, non-permanent, or casual laborers. Legal protections for labor do not apply to women working in non-formal employment. Women are also underrepresented in elected positions, educational institutions, and cooperatives or associations.

Access to credit and financial services is limited for both rural Zambians and women. Rural women, who are asset poor, face enormous obstacles in accessing financial resources. Collateral requirements and poor infrastructure preclude many women from accessing loans and other financial services to support emerging businesses.

Recommendations

Support formation of farmers' cooperatives or associations. The many Zambian smallholders engaged in horticulture production are not accessing high-value export markets because of sub-standard quality and limitations based on farm size. Formation of formal or non-formal cooperatives could improve access to inputs (i.e. credit, fertilizer, irrigation equipment, drying facilities, refrigeration/cold-chain technology) to enhance horticulture production. Higher volumes of combined product may enable farmer groups to build a stronger bargaining position when selling goods. The collective benefits of a cooperative are particularly important for women farmers whose access to resources and assets is limited.

Increase training that is specifically targeted at women. Women are constrained by mobility, poor credit access, insecure land tenure, and household duties. Decentralized training, where extension agents visit farms, could address women's geographic and scheduling needs. Skills and technology training enable women to grow higher quality products and engage in value-added processing. Training should also provide market information so women can select appropriate crops. Women-focused training could be combined with formation of associations or cooperatives to allow access larger, higher-value markets.

Facilitate connections between processing companies and women farmers. Out-grower schemes link individual or groups of farmers with businesses that process horticulture goods for further sale. Although partner businesses seek to maximize their profit, they have a vested interest in providing valuable training and technology support to farmers, ensuring that the business receives product of consistent quality and quantity without needing to negotiate with many buyers. Farmer groups can likely provide adequate quantities for out-grower schemes.

Provide women with technology that is easy to use and repair. Labor is often a limiting factor for horticulture production in rural Zambia and inputs like fertilizer are inconsistently available. Much farm work is done by hand, or occasionally by oxen; laborsaving technologies can drastically reduce women's workload, allowing them to focus on other components of production. Given infrastructure constraints, technology should be simple and training on maintenance and repair should be included.

Support and train more female farmers or extension agents. Vocational or technical training in extension offers many potential benefits, but the associated costs disproportionately exclude rural women from training opportunities. Women farmers have limited access to information and training through national extension and similar programs. Decentralized training on farms, training of trainers programs, or scholarships for women to learn extension skills could increase female extension officers and rural women's access to these services. Recipients of training or scholarships could be required to serve marginalized communities for a given time period. Establishing farmer field schools could serve a similar purpose and require less formal training.

Include legal rights information and relevant skills into training initiatives. Laws in Zambia are generally gender-neutral or promote women's rights. However, these laws are often not implemented, or enacted within a discriminatory social context that prevents women from actualizing all of the rights enshrined in the Zambian legal code. Equipping women with information about their rights, and the skills to support realizing those rights can create an environment where the broader benefits of horticulture can be garnered.

FEMALE REPRESENTATION

Representation in government

Female representation in elected positions in Zambia is low. Out of 150 members of parliament only 18 are female (Geloo, 2010; Gender Links, 2012; Mwale, 2012). Female representation at higher levels of government supports Zambia's gender mainstreaming initiative, which seeks to utilize women's positioning in government to prioritize more gender-centric issues. Increased female representation and gender sensitization training are intended to serve as tools for reducing gender disparity throughout all geographic regions and in all sectors (Republic of Zambia (GRZ), 2006). Because of Zambia's low population density, women who live in rural areas may have limited access to government officials at the regional and federal levels and are more dependent on local governments to meet their needs (Sichikwenkwe, 2012). However, at the local level, women lack significant representation in elected decision-making positions.

Zambia is signatory to the South African Development Committee's target of achieving equal representation of men and women in decision-making positions by 2015. In its 2011 elections Zambia fell drastically short of meeting this goal; the number of females in elected positions actually decreased from 7 to 5.9 percent. Of all the SADC countries Zambia has the lowest representation of women in local government, which includes elected membership to local councils. Over a third of these councils have no female representation (Gender Links, 2012; Gender Links, 2009; Sichikwenkwe, 2012).

Although there are no constitutional provisions that explicitly restrict women's participation in electoral politics, neither are there provisions to guarantee equal participation of women and men (Magagula, 2011). Article 11 of the Constitution includes a blanket non-discrimination clause guaranteeing everyone equal rights and freedoms. Yet the Constitution fails to identify solutions to common violations of this clause or provide mechanisms by which women's equal treatment can be ensured (Magagula, 2011). In its multi-sector gender profile the Government of Zambia cites the following as barriers to women's greater participation in the political arena: low levels of education and relevant skills, gender biased beliefs and practices, stereotyping, poor resource base, biased political party and electoral process structures, and low levels of confidence (GRZ, 2006). There is a higher concentration of men in positions of both formal and informal power within communities, leading to male-centric structuring of caucuses and political parties, reducing the accessibility of political candidacy for women (Geloo, 2010). The blanket non-discrimination clause does not address these types of barriers that prevent equal participation of women.

Representation in cooperatives or associations

Cooperatives in Zambia operate at four levels, with agriculture-oriented, small-scale farmers cooperatives predominant at the local level. These localized groups connect to district and provincial cooperative unions, culminating at the national level, the Zambia Cooperative Federation (International Labor Organization (ILO), 2009). This nested structure gives members the opportunity to both affiliate with and have part-owner status of the increasingly centralized cooperatives (ILO, 2009). Women members of formal cooperatives have a connection to national representation because of this structure. Formal cooperatives, in which both risk and funds can be pooled, are often the only way that women farmers in rural Zambia can access important inputs for improving productivity (Davis, 2000).

The creation of exclusive women's groups may be preferable in some areas where mixed groups may limit women's opportunities. Women-only cooperatives can prevent the replication of gender-biased power dynamics within the cooperative. Cooperatives may also facilitate empowerment of women through increased income, better access to markets, credit, and agricultural inputs (Davis, 2000; Hichaambwa & Tschirley, 2006; Tallontire, Dolan, Smith, & Barrientos, 2005).

Representation in the economy

Through a combination of socio-cultural norms and educational disparities women are overrepresented in less secure forms of labor, such as the informal sector, non-permanent or seasonal employment, and casual employment. A survey from 2003 found that 78 percent of formal sector employees were male. In comparison, 90 percent of employees in the informal sector were female (GRZ, 2006). This disproportionate concentration persists in horticulture (Smith, Auret, Barrientos, Dolan, Kleinbooi, Njobuy, Opondo & Tallontire, 2004). One drawback of employment in the non-formal sectors is that legal benefits enshrined in the Zambian legal code do not apply to informal workers, meaning existing legal provisions often fail to provide tangible benefits for women (Pearson, 2007; GRZ, 2006; Tallontire et al., 2005). Additionally, pay for non-permanent and non-formal work is typically lower (Pearson, 2007).

In the formal employment sector, men are often given supervisory or management roles with opportunities for advancement. Whereas women typically perform low-skilled, tedious tasks that are central to adding value to the product, such as harvesting or processing (Coles & Mitchell, 2011; Pearson, 2007; Tallontire et al., 2005). The combination of socio-cultural norms, lower educational attainment, reduced opportunities for upward mobility in the workplace, and low pay all contribute to 80 percent of women and children in Zambia living in poverty (Mwale, 2012). This is of particular concern for female-headed households, who comprise 19 percent of households in rural areas and show significantly greater rates of food insecurity (GRZ, 2006).

Representation in education

Zambia is making strides toward gender parity in primary education. However, there is a persistent gender gap in literacy as well as secondary and tertiary education. These are the areas in which many skills for permanent, formal sector employment may be acquired (GRZ, 2006; Social Institutions and Gender Index (SIGI), 2012). Sixty-two percent of adult females are literate compared to 81 percent of adult males (World Bank, 2013b). While higher levels of education may not directly result in higher productivity of land, they have been shown to increase adoption of specific practices that enhance productivity of cultivated areas, such as fertilizer use (Deininger & Olinto, 2000).

Skills-based training

Horticulture is an important source of employment and income in Zambia; nearly 83 percent of smallholders in Zambia grow fresh fruits and vegetables. Female-headed households comprise an estimated 19 percent of smallholder farms producing fresh fruits and vegetables and 17 percent of smallholders selling fresh fruits and vegetables. Sales from high value food crops (primarily fresh fruits, vegetables, and legumes) are the largest share of total crop sales income across all landholding quintiles. Tomato, rape, cabbage, watermelon, eggplant, and onion are the primary crops in the smallholder sector (Sitko, Chapoto, Kabwe, Tembo, Hichaambwa, Lubinda, Chiwawa, Mataa, Heck & Nthani, 2011).

Most producers of fresh fruit and vegetables are operating at an estimated 50 percent of the optimum productivity level and grow produce that is not saleable in formal markets because of sub-standard quality (Sitko et al., 2011). Although 80 percent of horticulture sellers identify horticulture as their most important income source, three-quarters of all sales are concentrated among only 20 percent of sellers (Hichaambwa & Tschirley, 2006). Large, commercial farms tend to be concentrated in areas with better market access and higher quality land, allowing them to dominate the horticulture sector and its benefits. Women typically work in the planting, weeding, irrigation, post-harvest preparation, and transportation stages of the value chain; these tasks are central to adding value, but do not allow women to capture the income benefits of those value additions (Mataa & Hichaambwa, ND; Sitko et al., 2011). Enabling more value-added capture for women smallholders represents an important opportunity for improving the lives of women.

Rural smallholders

Rural areas in Zambia face high levels of poverty, food insecurity, and are dependent on subsistence farming (Sitko et al, 2011; United States Agency for International Development (USAID), 2011). Smallholders in these areas face barriers of poor infrastructure for transporting goods, sharing information, accessing inputs, and acquiring technology and training (Davis, 2000). High quality seeds for horticulture crops and fertilizer are both more difficult to access in rural areas (Sitko et al., 2011). There is no national organization or committee for addressing rural smallholders' limited access, but there are privately and NGO-run programs focused on improving access to technology and market linkages (Mataa & Hichaambwa, ND).

Diversifying crops and engaging in value-added processing require access to seeds, relevant technology, market access, and corresponding training. Buyers often demand large quantities and delivery, which leaves women farmers poorly positioned to react to higher value market incentives (Tallontire et al., 2005). Standardization of all steps along the production chain is often required for codification or certification for large buyers, which may not be feasible for smallholders (Tallontire et al., 2005). Out-grower schemes are one method of providing support to smallholders, where farmers are linked to processors that provide technological training and support. This relationship between buyer and grower also facilitates capacity building such as business and entrepreneurial skills training (Sitko et al., 2011; USAID, 2011).

The need for training that targets women

Extension often excludes women because it targets landowners, who are typically male (GRZ, 2006). Additionally, agents frequently assume that the information they provide will be communicated to the rest of the household; this is often untrue and excludes women from important decision making activities (GRZ, 2006). One report from the Western province found that women only received visits from extension agents after the formation of formal women's farmer groups. In this case, most female heads of households had never seen an extension agent prior to the formation of the group (Rousse, 1996).

Women are underrepresented throughout public extension in Zambia. In 2011 only 14 percent of field level extension staff and 17 percent of subject matter specialists were female (Agricultural Extension and Advisory Services Worldwide, 2011). This is inherently tied to the gap in higher education, as low female enrollment in agricultural training programs results in low numbers of female extension officers, often negatively impacting female participation in extension services (GRZ, 2006).

Women contribute 70 percent of labor to the production and harvesting sectors of smallholder farming value chains but are often excluded from the marketing aspects when living in male-headed households. In these households women receive less than 20 percent of income derived from this process. In female-headed households, where women take on a more active role in marketing horticultural products, women's relative share of income is greater than 80 percent (Sitko et al., 2011).

In Zambia women are responsible for household-level provision, production, preparation, and management of food in addition to other household tasks, such as cleaning and caretaking. These tasks limit women's mobility, meaning that information and skills training must be adapted to meet women's schedules and needs. Women are often confined to lower-value markets within walking distance of their homes (Davis, 2000; GRZ, 2006). Information about pricing and transportation costs are of particular importance if women are to access high value markets to maximize the profit received on their investment (GRZ, 2006). Because women perform specific tasks that may be time sensitive (e.g. meal preparation) training formats that target men may be inaccessible to women.

LAND TENURE AND INHERITANCE

Zambia's abundant land resources and low population density create the potential for high agricultural productivity (Sitko et al, 2011). In addition to land constraints, horticulture productivity in Zambia is limited by poor infrastructure, restricting access to markets and laborsaving technologies that would allow for greater productivity. Agriculture comprises 21 percent of Zambia's gross domestic product and employs 72 percent of the country's labor force (USAID, 2010; FAO, 2013). An estimated 78 percent of women are engaged in agricultural work (Sitko et al., 2011). As of 2008 there were an estimated 1.1 million smallholder farmers with average holdings of approximately one hectare; smallholders comprise the majority of farming households in Zambia (USAID, 2010).

The most productive land is generally devoted to cash crops, whereas small-scale subsistence farmers usually hold the least productive land (USAID, 2010). Typically, men own land, while women access land through their husbands or their birth families (Machira, Bweupe, & Chiyombwe, 2011; GRZ, 2006; USAID, 2010).

Land tenure and inheritance legislation

There are two legal land tenure types in Zambia: customary and statutory. A majority of landholdings (84 percent) fall under customary tenure (GRZ, 2006; USAID, 2010). Under customary tenure individuals do not own land; instead, traditional authorities grant the use of land without temporal limitations to families, clans, communities, and increasingly individuals (GRZ, 2006; USAID, 2010). The rights of farmers are individualized, although the ownership is typically communal, and there is no formal documentation or land tax paid for customary holdings (USAID, 2010).

Statutory leaseholds of state land are primarily concentrated in urban areas, areas protected by the state, and other areas with developed industry and infrastructure (i.e. along railways and near mining-intensive areas) (USAID, 2010). Land may be transferred from a customary holding to a statutory holding, but the process is complicated, relatively expensive for rural smallholders, and requires approval of both the individual landholder and the traditional authority administering the customary holding (Machira et al., 2011; GRZ, 2006; USAID, 2010). Once customary land has been converted to state leasehold, customary rights are revoked and the land cannot be returned to a customary holding (USAID, 2010).

Zambia's Intestate Succession Act regulates inheritance. This law stipulates that 20 percent of assets of the deceased go to the spouse, with 50 percent going to children, 20 percent to surviving parents, and 10 percent to other dependents (Machira et al., 2011; USAID, 2010). However, this law does not apply to land under customary tenure because it is not privately held and cannot be inherited by other individuals (Machira et al., 2011; USAID, 2010). The broader community or clan to whom the customary holding was awarded determines inheritance of property. The law does not explicitly disadvantage women, but it permits discriminatory socio-cultural norms of clans and communities to impact decisions regarding land holdings of the deceased, which does impact women.

Women's access to land

Article 11 of the Zambian Constitution prohibits gender-based discrimination. However, Article 23 exempts otherwise prohibited discrimination under personal and customary law, both of which are central to land ownership and access. Scholars and practitioners argue that converting community-owned customary holdings to privately owned statutory holdings does not benefit rural women if they lack resources to purchase land and lose traditional access rights that are available via customary land holdings (Machira et al., 2011; Razavi, 2007). Privatization of land may, however, simplify the process of women inheriting land because state or statutory leaseholds may be sold, rented, mortgaged, or transferred (Razavi, 2007; GRZ, 2006). Because customary land is rarely owned by individuals it cannot be directly inherited. Widows are often victims of technically legal land grabbing, as customary holdings may be reallocated within the clan (Machira et al., 2011; SIGI, 2012).

Customary landholdings are administered at the complete discretion of traditional authorities without predetermined minimum standards and often "reflect structure of power and beliefs in the society" (Machira et al., 2011, p. 3). Local assumptions and norms about women and their role in society and the household limit individual land rights for women through traditional authorities (Machira et al., 2011; SIGI, 2012). Single women with children are becoming increasingly likely to be awarded customary lease rights by traditional authorities (Machira et al., 2011; USAID, 2010). However, married women are unlikely to receive a holding separate from that of their husbands without their husbands' consent.

The insecurity that rural women farmers in Zambia face because of inheritance laws presumably disincentivizes investing in land or in a community, as women may lose access to land in the event of death of a spouse or divorce. There is a link between land tenure and access, financial resources, and women's income. Socio-cultural norms bolster existing legal barriers hindering women's opportunities to increase and diversify their income and improve nutrition through land-based activities such as horticulture.

Access to credit and financial services

The financial sector in Zambia is small, but providers of informal financial services are increasing. In 2010 there were an estimated 16 commercial banks and 71 non-bank financial institutions (NBFIs) (Melzer, Agasi, & Botha, 2010). NBFIs occupy the semi-formal financial sector; they lack full banking licenses and are not supervised by national regulatory agencies but provide financial services in the form of insurance firms, pawn shops, check-cashing locations, money lending, currency exchange, and microfinance institutions (MFI). Estimates from 2011 show MFIs and currency exchange facilities to be the most rapidly growing NBFIs in Zambia (Deutsche Gesellschaft für Zusammenarbeit (GIZ), 2012).

A 2009 Finscope Survey in Zambia estimated just over 23 percent of the adult population has access to formal financial services, while 14.1 percent has access to informal financial services (GIZ, 2012). The government recognizes that utilization of financial services is low in Zambia; the deputy governor of the Bank of Zambia announced the goal of increasing financial inclusion by 50 percent by 2015 (Kankasa-Mabula, 2012). There are many constraints to accessing financial products and services in Zambia, including disparities between rural and urban areas as well as women and men. While the government may be well positioned to address some of these barriers, others stem from the policies of the financial institutions.

Rural access barriers

Customary law and practices that discriminate against women are more prevalent in rural areas. Therefore, disparities between urban and rural areas have a disproportionate and negative impact on women who may bear the dual burden of rural access disparity and gender-based discrimination. Zambia's urban population is more likely to take advantage of financial services. In urban areas 32 percent of adults utilize formal financial products and services compared to 18 percent in rural areas (GIZ, 2012). Extending financial services to rural areas of Zambia can be difficult due to low population densities and poor infrastructure. Fifteen of the country's districts lack bank branches entirely (Arora, Saasa, Stone, Carpio, Williams, & Grossman, 2012).

The Government of Zambia has sought to develop rural finance policies and strategies, with explicit emphasis on expanding access and creating an environment that supports expansion of both formal and informal financial service providers (Arora et al., 2012). Providing financial services in rural areas includes identifying services with low infrastructure needs. Cellular phone access is fairly widespread throughout Zambia with much of the necessary infrastructure in place. Mobile banking via cellular phones is realistic in Zambia and represents an opportunity for better closing the urban and rural gap in financial service access (GIZ, 2012).

Automated teller machines (ATM) also require less infrastructure than many other financial services offered only in bank branches, making them an important component of promoting rural access to financial services. A national switch is a mechanism that connects stand-alone ATMs with the broader banking system. Zambia's lack of a national switch means that ATMs, which provide rural financial service access, are not connected to the broader banking system. This isolation of ATMs poses problems for true integration of rural areas to national financial efforts (Arora et al., 2012). These low-infrastructure, decentralized technologies represent opportunities for improving rural women's access to financial services.

Women's access to financial resources

Women's access to financial resources in Zambia is limited, preventing women from reaping the benefits of horticulture production. According to the Bank of Zambia's deputy governor: "Access to affordable financial services—especially credit and insurance—enhances livelihood opportunities and empowers women and other marginalized groups to take charge of their lives as well as improve their social and economic equity" (Kankasa-Mabula, 2012). The deputy governor identified the following obstacles that women entrepreneurs face in accessing financial services: lack of collateral, discriminatory property rights, financial illiteracy, lack of financial products and services appropriate for women, inadequate financial skills, lack of banking facilities, prohibitively complex procedures and forms, high costs, concentration of women's businesses in informal and low-value sectors, and a lack of information to help identify women-specific financial products and services (Kankasa-Mabula, 2012).

Female access to financial services was 34 percent in comparison to 41 percent for males, according to a national 2009 survey (GIZ, 2012). When only formal financial services were considered, women's access decreased to 12 percent, while access of their male counterparts dropped to 17 percent (Kankasa-Mabula, 2012).

Women may seek financial services to improve their livelihoods, especially by expanding or enhancing their businesses. However, women-run firms in Sub-Saharan Africa tend to be smaller, informal, and operate in lower value-added sectors than those run by men. A portion of the disparity between female- and male-run firms stems from women's less secure property rights and reduced capacity to access their legal rights (Women, Business, and The Law (WBL), 2011). The prevalence of women-run firms in informal sectors translates to reduced income and other assets that may be used as collateral, limiting women's ability to access loans to diversify income and expand horticulture production.

The Government of Zambia is in a position to address a number of legal constraints that affect women's access to credit. Laws and practices regulating land tenure, division of property, and inheritance affect access to financial services. Ultimately, "[a]ccess to finance is limited by rigid collateral requirements. Many financial institutions accept only real property as collateral, which limits access" (Arora et al., 2012, p. 20). Customary land rights are often not registered, meaning they may not serve as collateral in accessing finances (Machira et al., 2011). The indirect rights of land access that women have through their spouses or birth families are not typically accepted as collateral (Machira et al., 2011). Women often lack the resources to compete in privatized land markets because they are discriminated against in acquiring land as well as acquiring financial resources to help them maximize the land they are able to access, even if they do not explicitly own that land.

Not all constraints facing women are directly related to government policies. Many of these constraints are policies from specific financial institutions that focus on urban, high-earning customers (Melzer et al., 2010). Current financial service provider models are often unable to accommodate the unique needs of rural customers whose incomes are smaller (GIZ, 2012). One example is "know your customer" (KYC) regulations, which are implemented by banks to mitigate risk of illegal activities. KYC policies often mandate customer identification and verification that may preclude servicing marginalized populations, especially rural residents who often lack proper identification (GIZ, 2012; Melzer et al., 2010). Banks frequently have minimum balance requirements. Such requirements can deter potential users who perceive these minimums as beyond their reach or are unable to meet the minimum baseline needed to open an account (Melzer et al., 2010).

Perceptions about financial institutions impact the use of financial services. Rural customers, including women, are more likely to be financially illiterate, which makes accessing financial services more challenging (GIZ, 2012). Perceptions about banks and their accessibility also contribute to lack of use. For example, 42 percent of micro, small, and medium enterprises (MSMEs) identified that the bank was too far away, and 47 percent of MSMEs cited that the line for accessing the bank was too long (GIZ, 2012; Melzer et al., 2010).

NBFIs and semi-formal financial services

Non-bank financial institutions (NBFIs) provide growing opportunities for closing the financial services access gap between rural and urban populations, as well as between women and men. Informal financial service providers increased their share of the financial services market in Zambia from 11.3 percent in 2005 to 14.1 percent in 2009 (GIZ, 2012). The Bank of

Zambia has established a licensing program to allow MFIs to become deposit-taking institutions rather than just microfinance loan offices (Arora et al., 2012). This shift may improve financial access in rural areas, where NBFIs are more prevalent, by enabling MFIs to provide banking services and bridge the informal and formal markets. MFIs are often more eager to work in rural areas and expand financial service access than their formal banking counterparts, who tend to prefer traditional models that serve large businesses in urban trading centers (Arora et al., 2012; Melzer et al., 2010).

Microfinance may represent an important tool in efforts to improve access to financial services for women and individuals in rural areas but there are too few institutions to effectively meet the needs of all marginalized groups. Additionally, many areas remain underserved because their income is too small and irregular to warrant regular financial services (Melzer et al., 2010). Access to financial services in Zambia is limited and small-scale female farmers in rural areas may face some of the greatest hurdles in accessing financial services. Financial cooperatives, such as SACCOs, are still relatively underdeveloped in the country, with few cooperatives operating sustainably and limited performance information available. Because informal financial organizations are limited in number, they often struggle to provide high-quality services, and to retain staff. NBFIs may still charge fees beyond the reach of many rural individuals, especially women (Arora et al., 2012; GIZ, 2012). MFIs, like their formal banking counterparts, often give women smaller loans than originally requested, making it difficult for women to carry out their business plans (GIZ, 2012).

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APPENDIX A: LITERATURE REVIEW

This literature review examines the global trends for women in agriculture and horticulture to identify and better understand the legal and policy barriers affecting women working in horticulture in selected Feed the Future countries: Guatemala, Nepal, Tanzania and Zambia. Research for this review highlighted four barriers common around the world. These barriers include: inadequate female representation (both politically and socially), a lack of access to extension services (skills-based training in agriculture and business development, and tools and technology), as well limited land tenure, and financial resources and credit. By identifying legal and policy barriers that challenge women in these developing countries in the production, processing, marketing and the sale of horticultural goods this report supports the Horticulture Collaborative Research Support Program (CRSP) at the University of California Davis in achieving its mission of increasing food security, improving nutrition, and bettering health outcomes through horticultural development. Horticulture can provide opportunities for women to generate revenue and diversify their income base, leading to improvements in their welfare and that of their children. While there is limited literature specifically addressing barriers women face in horticulture, important insight can be gathered from research on obstacles to women succeeding in agriculture more broadly. Exploring global agriculture trends for women in developing countries offers perspective on common obstacles as well as strategies and solutions to remedy these issues.

INTRODUCTION

This discussion focuses on providing a brief overview of some of the global trends around legal rights and reform and of key barriers women in agriculture and horticulture face. While the purpose of this report is to identify policy barriers, many of the contributing factors are social, cultural, and economic and reflect obstacles arising from policy implementation rather than explicitly discriminatory policies. The Food and Agriculture Organization of the United Nations (FAO, 2011) advocates bridging gender gaps in developing countries as a strategy to reduce poverty and hunger. Additionally, the FAO emphasizes the importance of assessing how agriculture policy affects women differently by understanding the numerous challenges women face gaining access to the same resources and opportunities as men. Bridging critical gender gaps could improve agricultural yields by 30 percent and thereby reduce the number of people who go hungry by as much as 17 percent (FAO, 2011).

LEGAL BARRIERS

Many countries have begun to make the changes necessary to close these gender gaps. These changes are often geared toward promoting gender parity between men and women. Several countries introduced a small claims court to provide localized adjudication services. Other countries reduced or eliminated minimum requirements for loans with credit bureaus. Many countries passed or amended laws governing maternity leave. Some countries also introduced employment anti-discrimination laws (Women, Business and the Law, 2011). These changes demonstrate the momentum globally to create gender equality.

Another example of recent legal changes can be seen in southern Africa. In 2008 the Southern African Development Community (SADC) signed the Gender and Development Protocol. This protocol is an effort to enshrine gender equality in the countries' constitutions by examining and repealing laws that discriminate based on gender, as well as work to improve maternal mortality rate, create policies that promote gender equality accessing economic resources, prohibit gender based violence and address gender issues relating to HIV and AIDS (Weisfeld-Adams, 2008). The SADC aims to have these policies in place by 2015. Eliminating laws that discriminate based on gender is critical, but it is not enough. Taking gender-based legal reform a step further, the International Food Policy Research Institute (IFPRI, 2009) recommends having an anti-discrimination law in place and a plan for how to enforce it (Fertziger, Grebmer, Nestrovora, Pandya-Lorch, and Yohannes, 2009).

Inequality persists despite legal changes in recent years. The biannual Women, Business and The Law's gender parity report identifies changing and eliminating laws that foster inequality as a first and necessary step in the right direction; however, challenges enforcing these legal changes remain (2011). In countries where both customary and statutory laws are valid, particularly when those laws conflict with one another, it is difficult to navigate between the two systems. A lack of institutional capacity is another challenge to enforcement in developing countries (Women, Business and the Law, 2011). Developing countries may lack offices and staff in rural areas to enforce the existing laws protecting women's rights. In the absence of strong policy implementation in rural areas, even policies aimed at reducing gender disparity fail to improve conditions for many women.

Women facing discrimination may be unable to access legal services, limiting women's ability to benefit from equal opportunities afforded to them. Education about how to access and utilize legal systems and support mechanisms can play a role in overcoming this persistent challenge (WOCAN, El-Fattal, 2012). Service centers in rural areas where simple legal business transactions can be completed (i.e. filing the paperwork to start a new business without the need for a notary or lawyer) would be one way to improve access. Rural women's lack of mobility, time, money, and literacy all affect their ability to complete simple business transactions (El-Fattal, 2012).

Female Representation

Some countries have adopted constitutional mandates to ensure that a specified percentage of women hold government office. Female representation may help ensure women have access to their legal rights. Additionally, female political representatives may work to review current policies and create more favorable policies for female farmers.

Women's groups and community based-organizations can help build social capital. They may operate as cooperatives, savings associations, and marketing groups. One group in Kenya pooled their land, increasing each individual's access to land and credit and subsequently control over their incomes (FAO, 2012). Political representatives who support enforcing women's legal rights, and networks that build social capital, are important to reducing gender disparities.

Extension Services

Another barrier that must be addressed is women's access to agriculture extension services. Noting the gaps in extension services is a critical step to understanding women's limited access to assets. Extension services should tailor their outreach to meet the unique needs of women, recognizing women's limited time and mobility and educational disparities (El-Fattal, 2012; IFPRI, 2008). For social and cultural reasons male extension workers tend to educate male farmers. Increasing the number of female extension workers would improve women's access to extension services according to the IFPRI (2008). In addition to growing food to feed their families and earn income, women often have responsibilities running households, securing fuel and water, as well as caring for children and other family members (Weisfeld-Adams, 2008). Without extension services women miss opportunities to improve farm yields and increase their incomes.

Women's limited access to land and input resources prevents women from enjoying the benefits of participation in agriculture value chains, particularly in high-value agricultural production (Mehra and Rojas, 2008). Participation in value-chains requires production of goods in large quantities, which are difficult for asset-poor women to meet. A 2002 study by McCulloch and Ota documented the success available to small horticulture farmers participating in exports through modern supply chains in Guatemala, Kenya, and Indonesia (as cited in Mehra & Rojas, 2008, p. 5). Companies typically contract with men; this limits women's opportunities to access markets dominated by large companies (Mehra and Rojas, 2008).

Land Tenure

According to the SDD FAO, women produce over 80 percent of the world's food supply but own one percent of the land (2013). Access to land poses a significant barrier for women, affecting the size of their fields and the quality of the land they farm. Barriers to accessing land are often reflected in marital property rights, rights and access to legal transactions, inheritance practices, credit access, and a woman's ability to appeal to the judicial system (SDD FAO, 2013).

Landownership for women may be improved by ensuring married couples have joint ownership of property, and that property titles allow space for more than one name (El-Fattal, 2012). Birth certificates and other forms of identification are important in securing ownership to land; rural women may not possess this formal documentation, limiting their ability to own land (El-Fatal, 2012). The International Center for Research on Women suggests that women who have control over land and subsequently their finances are more successful at providing for their families and increasing the productivity of their farms (2012).

Financial Resources and Access to Credit

Rural women have unique financial needs and circumstances that limit their ability to access insurance, savings and credit opportunities. Allowing women to use moveable or non-land collateral such as equipment, jewelry, and livestock could be used to expand the credit available to women (El-Fatal, 2012). In the absence of credit access, women may be unable to invest in increasing farm productivity through the purchase of equipment, seed, and fertilizer (Bill & Melinda Gates Foundation, 2012).

Conclusion

Changes in laws and policies around the world reflect efforts to reduce codified gender-based discrimination. Despite new laws and amendments, inequalities persist, both enshrined in legislation and enabled by inconsistent implementation and enforcement. Women in horticulture will benefit from addressing these barriers, improving their ability to increase income and bolster health and nutrition.

Appendix 8
Technology toolbox

Technology Toolbox
for Horticultural Development

January 2014




Feed the Future Innovation Lab for
Collaborative Research on Horticulture

USAID FROM THE AMERICAN PEOPLE

HortCRSP

UCDAVIS UNIVERSITY OF CALIFORNIA

Visit http://hortcrsp.ucdavis.edu for more information.

Horticulture Innovation Lab

The Feed the Future Innovation Lab for Collaborative Research on Horticulture builds international partnerships for fruit and vegetable research to improve livelihoods in developing countries. Our program began in 2009 when USAID selected UC Davis to lead a $15 million, five-year program, then called Horticulture CRSP. For the past four years, our projects and our management team have been helping the world's poorest people break out of a persistent cycle of poverty through the production and marketing high-value crops. Improving livelihoods—through higher profits and diversified, nutrient-rich diets—is a major goal for the Horticulture Innovation Lab's research efforts around the world. Our projects span the horticultural value chain. Our 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. Our projects are active in more than 30 countries in Latin America, Africa, and Asia. To scale-up the technologies that we research, the Horticulture Innovation Lab has established Regional Centers in Thailand, Kenya, and Honduras. Since inception, our projects have trained more than 31,000 people (54% women) and benefited 6,169 rural households.

Technology and Innovation
Horticulture Innovation Lab Approach

Given the complexity of horticulture, innovative "leapfrog" technologies can reduce constraints and input costs that limit the ability of smallholder farmers to achieve maximum profitability in the production and marketing of high-value horticulture products. The Horticulture Innovation Lab projects have researched and adapted proven technologies and have come up with a number of new and novel leapfrog technologies and innovations that will reduce poverty and hunger.

The work of innovation in horticulture is to make something better, more efficient, more nutritious, more productive or more profitable. The Horticulture Innovation Lab believes that specific technologies and innovations have the ability to solve problems and challenges and 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 Lab focuses on technologies that reduce on-farm costs, use labor more efficiently, empower women, build partnerships, and sustainably use natural resources.

We know that often the simpler a technology is, the more likely its up-take and adaption to local conditions will be. Access to materials, final cost, and actual and perceived benefits all play an important role in farmer adoption. Our research addresses all of these aspects of technology design and dissemination.

Technology toolbox

The Horticulture Innovation Lab's "technology toolbox" is a selection of tested and proven technologies including those that have been developed and/or demonstrated in Horticulture Innovation Lab projects. Currently Horticulture Innovation Lab scientists are adapting a range of innovative technologies aimed at significantly improving the profitability of horticultural production for smallholder farmers. Through the Horticulture Innovation Lab Regional Centers, these technologies will be deployed, adapted to local conditions, tested on farms and extended to local stakeholders. Each of the centers will add local innovations to the toolbox and will continue to research and adapt these technologies for local use while following rigorous research methods and community participation.

DESIGN and SYSTEMS

Technologies and innovations come in a variety of forms. "Hard" technologies are devices, prototypes and designs that improve our life and in some way change a 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. The Horticulture Innovation Lab works to create both innovations within systems and designs for improving horticulture.

Technologies for horticultural development

Solar drying adds value to crop surplus

Fruits and vegetables are highly profitable commodities for both small- and large-scale farmers. These crops are often harvested in high volume over a short period of time, when quality is high but prices are low. Rates of loss and waste in fresh produce can be quite high, especially in developing countries. Solar drying of fresh fruits and vegetables is a simple processing technique that adds value to crop surpluses, preserves and extends food supplies, empowers smallholders and creates rural employment.

Chimney solar dryer design

From Horticulture Innovation Lab researchers at UC Davis, the chimney solar dryer is designed to provide efficient drying even in hazy or partially cloudy conditions, using inexpensive and readily available materials. Other features of this design include:

- The chimney ensures continuous air flow around the product, thus increasing the speed of drying compared to other designs.
- This design's large heat-collection area ensures high temperatures and rapid water removal.
- Flexible design allows users to modify tray depth and size to fit consumer demands.

Designed by UC Davis researchers for the Horticulture Innovation Lab, the chimney solar dryer has already been constructed by additional USAID-funded projects, including this one in Uzbekistan.

Benefits

- Cost-effective, small-scale processing option for smallholder farmers
- Easily modified to suit specific requirements of different products and climates
- Provides benefits of solar drying even in hazy or partially cloudy conditions
- Dries produce twice as fast as cabinet dryer designs (2.5 days instead of 5 days)

Basic costs

- Clear plastic, 2-4 mm thick
- Dark-colored row cover fabric or black plastic
- Food-grade plastic mesh or galvanized screen
- Plywood
- Basic carpentry materials

Materials can be purchased for less than $150; however, costs are subject to local variation.

What's next? Scaling up

- **Education:** Train farmers and farmer groups on construction and use of chimney solar dryer, in addition to the principals and economic benefits of drying produce.
- **Adoption:** Connect with cottage industry to market and sell quality dried produce.
- **Investment:** Work with NGOs, extension workers and development partners to promote and demonstrate the chimney dryer.

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Technologies for horticultural development

Solar pumps improve irrigation options for farmers

Rain-fed agriculture can be a high-risk venture, particularly with changing rainfall patterns and high-value crops such as fruits and vegetables. Irrigated cropland is twice as productive as rain-fed agriculture (World Development Report 2008), but many farmers do not have access to irrigation infrastructure, including a nearby water source and power to move the water to and through their fields. Combining drip irrigation kits, newly affordable photovoltaic panels and off-the-shelf, 12-volt pumps can result in a cost-effective system for supplying water for irrigation. Solar-powered irrigation has the potential to increase incomes dramatically, particularly for the most remote producers.

How the solar pump system works

A 50-watt photovoltaic solar panel can power a 12-volt pump, which can move 1,300–2,600 liters per hour (or 350–700 gallons). Standard plastic fittings and half-inch piping connect these elements to a water saving tank of 500–1,000 liters. A sturdy stand should be built for the water tank to provide gravity flow, and a frame should also be constructed to provide the best angle for the solar panels. Multiple filters are needed to protect the life of the pump and minimize clogging in sprinkler emitters and tubes. A solar pump combined with affordable drip irrigation kits can be used with a wide variety of high-value crops to increase water efficiency, minimize fertilizer loss, and irrigate hilly terrains.

A solar-powered pump—shown here at the Horticulture Innovation Lab's Regional Center at Kasetsart University—can enable drip irrigation in remote locations, where access to electricity, high costs of securing fuel, and distance from a water source can make irrigation prohibitively difficult for smallholder farmers.

Benefits

- Solar irrigation can increase incomes dramatically, particularly for remote producers with inconsistent access to electricity or fuel.
- Pump irrigation reduces labor for water delivery.
- By targeting water at a crop's roots, drip irrigation can reduce weed and disease pressures, and increase efficiency of chemical applications.
- Drip irrigation significantly increases water use efficiency.

Basic costs

- Solar panels and frame
- 12V water pump and electric wire
- Water level switches
- PVC piping, connectors, valve
- 500L water storage tank and stand
- Filters
- PVC cutter
- Irrigation tape or tubing

These basic materials are available from local suppliers at low costs.

What's next? Scaling up

- **Education:** Continue to provide training through the Horticulture Innovation Lab Regional Centers and our network of partners.
- **Research:** Test components available in partner countries to find the most effective and affordable combinations.
- **Partnerships:** Work with the Horticulture Innovation Lab's network of partners to provide training, consulting and extension services to small-scale fruit and vegetable growers.

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Technologies for horticultural development

CoolBot provides inexpensive, effective cooling

In many developing countries, the rate of postharvest loss for fruits and vegetables exceeds 50 percent. Cool storage can greatly reduce these losses, increasing income for farmers. Cool storage is virtually non-existent due to the high cost of equipment and lack of knowledge about the benefits of cooling produce. Temperature control alone can extend shelf life by weeks or even months. Farmers who can store their produce longer can take advantage of better prices, as market prices can fluctuate dramatically over time.

How the CoolBot works

The CoolBot was developed by Store It Cold as an affordable way for small-scale producers to cool products on their farms. Horticulture CRSP has tested cool rooms equipped with the CoolBot on three continents.

Neeru Dubey, of Amity University, shows a CoolBot working in India during a Horticulture CRSP project testing local installation in multiple countries, including India, Honduras and Uganda.

The equipment:

- Overrides an air conditioner's temperature gauge, tricking it into working harder while preventing components from freezing.
- Converts an insulated room and an inexpensive, readily available, window air conditioner into a cool room.
- Substantially reduces the cost of a cool storage environment for fruits, vegetables, flowers and other products.
- Makes cool storage a viable option for farmers, cooperatives and market groups in the developing world.

Benefits

- Farmers can store produce to sell in the off-season when prices are higher.
- Improved cold storage possibilities will stabilize fruit and vegetable prices, giving consumers access to nutritious fresh produce all year.
- Farmers are better protected from erratic market prices.

Basic costs

- $299 CoolBot
- $700 Air conditioner
- $2,000 Insulated room
- $200 Electricity costs/month

These costs are subject to local variation. Identifying local, effective options for insulated rooms is one objective of a related Horticulture CRSP project.

What's next? Scaling up

- **Education:** Increase postharvest training and direct farmer outreach.
- **Adoption:** Work with industry, farmer cooperatives, local and regional markets, and bulk purchasers to adopt the CoolBot.
- **Investment:** Research innovative investment options for farmers and groups. Identify entrepreneurs eager to promote the CoolBot.

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Technologies for horticultural development

Facilitated solarization reduces weeds, pests in a week

In developing countries women often carry out the time- and labor-intensive work of hand-weeding, and pests are often controlled with chemicals by small-scale farmers with little knowledge of proper handling or application. Misuse of pesticides and herbicides can result in water contamination, pest resurgence and unsafe produce. Soil solarization is a well-studied technique that can reduce heat-sensitive weeds, pests, and diseases without chemicals. But this process typically requires a minimum of six weeks of sunny skies and high temperatures, which can be difficult and costly for smallholder farmers with a continuous rotation of crops. Instead, facilitated soil solarization is a technique that has shown promise for control of heat-sensitive weeds and soil-borne pests and diseases, in only one week.

How facilitated solarization works

Facilitated solarization reduces the time needed by covering the clear solarizing plastic with an insulating layer at night to reduce the heat lost during cool nights. First, prepare beds and irrigate soil down to about 30 cm, as wet soil better conducts and holds heat. Then place clear plastic directly over the soil, and secure by burying the edges in a trench around the beds. Just after the hottest time of the day, apply insulation materials, such as wool, fiberglass, old blankets, bags packed with rice hulls or chicken feathers. Remove the insulation in the morning as the sun is rising and store in a safe location for re-applying in the late afternoon.

Facilitated solarization can speed up the standard soil solarization process with the addition of insulation to reduce heat loss at night.

Benefits

- Reduces need for hand-weeding
- Reduces soil-borne pests and diseases without using chemicals
- Simple and cost effective, using only clean solar energy, clear plastic and reusable insulation
- Reduces the time a field needs to remain unplanted for traditional solarization

Basic costs

- **Clear plastic**: 1.5–2 mm thick, optimal to provide greatest heat transfer while reducing tearing
- **Insulation materials**: Industrial insulation, blankets, packed rice hulls or chicken feathers

The costs of these items are subject to local variation.

What's next? Scaling up

- **Further research:** Conduct adaptive research in different climate zones to fine-tune recommended exposure time, identify a more complete spectrum of weeds and soil-borne pests that are affected, and identify affordable, effective insulation options for small-scale growers in resource-poor areas.
- **Adoption:** Work with NGOs, extension agencies, farmer groups and other trainers to demonstrate the efficacy of facilitated soil solarization.

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Technologies for horticultural development

Pest-exclusion nets protect crops to boost yield

Insect pests reduce crop yield by attacking crops and by transmitting diseases. Access to training and information on effective use of pesticides can be rare for many smallholder farmers. As a result, farmers often sell damaged produce or use high levels of pesticides, which can be dangerous to both farmers and consumers and can increase insect resistance to pesticides. Pest-exclusion nets can have a major impact in addressing many of these problems.

How the nets work

Pest-exclusion nets create a barrier that protects vegetables against pests and associated diseases. The nets are easy to use and can also serve as floating row covers to control temperature, light, relative humidity and soil moisture for plant production. The nets are low-cost and can be reused for 3–5 years. Pest-exclusion nets are made and marketed locally by mosquito net manufacturers.

Pest-exclusion nets are being used in Kenya and Benin to increase yield and quality in crops such as cabbage, with research and support from a Horticulture CRSP project.

Benefits

- Improve yields and vegetable quality
- Provide an inexpensive and safe method of managing insect pests
- Improve ambient growing conditions and water-use efficiency, enhancing yield and produce quality
- Reduce reliance on toxic and expensive pesticides that impact environmental and human health
- Increase market opportunities for domestically produced textiles

Basic costs

- Netting \$60-99 per 150 m^2

Costs are subject to local variation and depend on whether nets are impregnated with insecticide or not, lightweight or heavyweight.

What's next? Scaling up

- **Education:** Train farmers through field trials and demonstration plots.
- **Adoption:** Highlight production and income gains. Increase product availability within the region.
- **Investment:** Work with industry and entrepreneurs to promote the nets.

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Technologies for horticultural development

Drying beads save high quality seeds

In tropical climates, high humidity causes rapid seed deterioration, resulting in poor stand establishment, lower productivity, reduced market value and a disincentive to invest in improved seeds. Under humid conditions, drying under the sun and other traditional methods cannot reduce seed moisture sufficiently to maintain seed quality. For every 1 percent increase in seed moisture content, seed longevity is reduced by approximately half.

How drying beads work

Drying beads are a product developed by Rhino Research using zeolite. When used with airtight containers, the drying beads provide a simple, inexpensive and widely adaptable method for drying horticultural seeds and maintaining high seed quality during storage. The beads can be reused indefinitely by heating between uses.

Horticulture CRSP projects are introducing the use of zeolite-based drying beads to dry and store horticultural seeds in Nepal, Bangladesh, Kenya, Tanzania, Uganda and Rwanda.

Benefits

- Drying beads enable farmers to dry seeds to very low moisture contents under ambient conditions, thus improving seed quality.
- Farmers plant better seeds that have higher germination rates and increased yield capacity.
- Better seeds lead to healthier crops that require fewer pesticides, saving farmers money.
- Farmers have greater incentive to invest in improved cultivars as the returns on their investment are higher.
- Local seed systems build capacity by creating a larger market for locally produced and improved cultivars.

Basic costs

Drying beads	$10-20/kilogram
Airtight container	$2-10/each
Oven	Varies

These costs are subject to local variation. Identifying additional, energy-efficient heating options for bead recharge is one objective of continuing research.

What's next? Scaling up

- **Education:** Train seed saving groups and seed banks on the value and use of the drying beads.
- **Adoption:** Work with industry, non-governmental organizations, seed vendors and distributors to use the drying beads.
- **Investment:** Identify partners and entrepreneurs willing to invest and promote drying beads.

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