Feed the Future Innovation Lab for Collaborative Research on Horticulture

Annual Report 2014-15

USAID FROM THE AMERICAN PEOPLE

HORTICULTURE INNOVATION LAB

UC DAVIS UNIVERSITY OF CALIFORNIA

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Management Entity information

The Horticulture Innovation Lab builds international partnerships for fruit and vegetable research to improve livelihoods in developing countries. The program began in 2009 when the U.S. Agency for International Development selected University of California, Davis to lead a $14.6 million, five-year program (then called the Horticulture Collaborative Research Support Program, or Horticulture CRSP). The university was awarded a subsequent phase for the Horticulture Innovation Lab until 2019 for $18.7 million. The program team and its projects help the world's poorest people break out of a persistent cycle of poverty by improving smallholder farmers' abilities to grow and sell high-value crops. Improving livelihoods—through higher profits and diversified, nutrient-rich diets—is a primary goal for the Horticulture Innovation Lab's research efforts around the world. The program's work is guided by ensuring gender equity, improving information access, targeting innovative technologies and increasing research capacity.

Horticulture Innovation Lab projects span the value chain of fruit and vegetable production, from seed systems to postharvest processing. Individual projects are led by U.S. university researchers with collaborating partners in developing countries, with funding from $200,000 to $2 million. Collaborations have included more than 18 U.S. universities and 200 organizations in more than 30 countries of Latin America, Africa, and Asia. Through partnerships and collaborative research, the program also aims to build the capacity of researchers, institutions and farmers to advance horticultural science. To scale up research results and new horticultural technologies, the Horticulture Innovation Lab funds two Regional Centers in Thailand and Honduras.

Management Entity

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

Members of the management entity:

- Elizabeth Mitcham, director
- Amanda Crump, associate director
- Michael Reid, leader of technology and innovation
- Mark Bell, leader of communications and information transfer
- Heather Kawakami and Sara Saberi, accounting and fiscal analysts
- Britta Lilley Hansen, program officer
- Angelos Deltsidis, international postharvest specialist
- Diana Puccetti, office management and event planning
- Brenda Dawson, communications coordinator
- 2014-15 paid and unpaid student staff: Elyssa Lewis, Kelsey Barale, Namho Kim, Emily Baker, Liz Hohenberger, Azia Hasan, Anthony Phan, Elise Brockett, Robert Duggan, Emily Kovar, Gianina Martynn, Owen Cortner, Mariah Cosand, and Jason Tsichlis

- Special projects staff: Amrita Mukherjee and Ron Voss, Bangladesh potato storage project and Meagan Terry, MásRiego project

Technical and/or advisory committee information

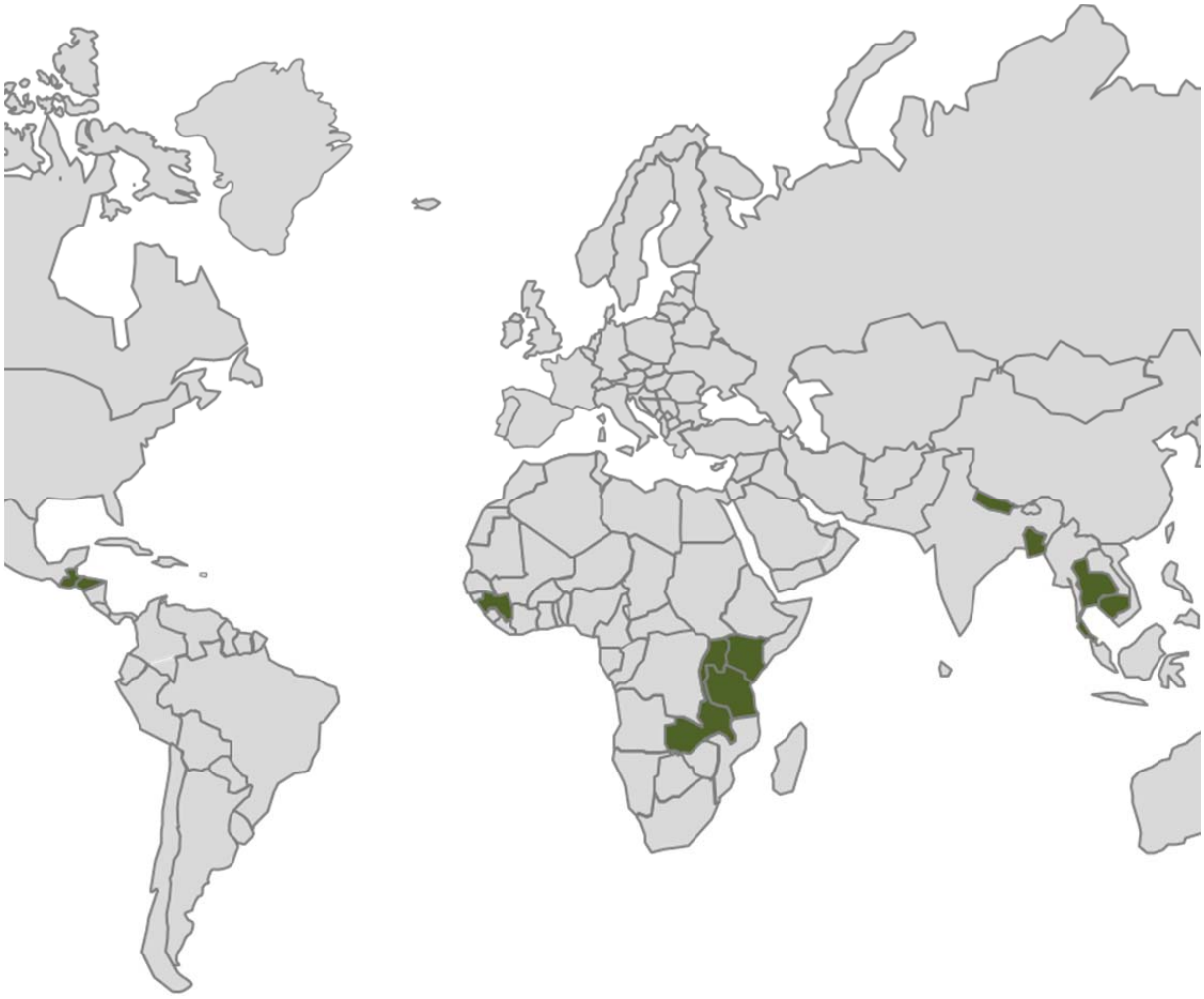
The Horticulture Innovation Lab's International Advisory Board (IAB) is the program's senior advisory council. The IAB ensures that Horticulture Innovation Lab priorities are met and integrated for maximum effectiveness. The IAB helps set priorities and ensure that USAID, Global Horticulture Assessment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

Members of the Horticulture Innovation Lab International Advisory Board:

- J.D.H. Keatinge, AVRDC-The World Vegetable Center
- Josette Lewis, University of California, Davis
- Julio López Montes, Zamorano Pan-American Agricultural School
- Bob Nanes, consultant
- Robert Paull, University of Hawai‘i at Mānoa
- Idah Sithole-Niang, University of Zimbabwe
- Sally Smith, University of Adelaide
- Detlef Virchow, Global Horticulture Initiative
- Walter Bowen, University of Florida
- L. George Wilson, North Carolina State University

Location of 2014-15 project activities

The Horticulture Innovation Lab currently works in Bangladesh, Cambodia, Guatemala, Guinea, Honduras, Kenya, Nepal, Tanzania, Thailand, Uganda and Zambia. During the period captured by this report, we have awarded small Trellis projects to organizations in Bangladesh, Ethiopia, Ghana, Guatemala, Kenya, Malawi, Mali, Nepal, Thailand, and Zambia. Below is a map of countries where the Horticulture Innovation lab is currently active (this does not include the Trellis projects).



Program partners

United States - Michigan State University; North Carolina A&T State University; North Carolina State University; Pennsylvania State University; Purdue University; Rutgers University; The Ohio State University; Tufts University; University of California, Davis; University of Florida; University of Hawai'i at Mānoa; University of Wisconsin-Madison

Bangladesh - AVRDC – The World Vegetable Center; Bangladesh Agriculture University; CIP; DAI; Patuakhali University of Technology; PRIDE; World Fish

Cambodia - Agricultural Development Denmark Asia (ADDA); Royal University of Agriculture (RUA)

Ethiopia (Trellis only) - SANRM

Ghana (Trellis only) – KayFund; KITA; Tip Top Foods Ltd.

Guatemala - Catholic Relief Services; Counterpart International; Guatemalan Ministry of Agriculture; ILAG; USDA

Guinea - Peace Corps

Honduras - Honduran Ministry of Agriculture and Livestock; iDE; Panamerican Agricultural School, Zamorano

India - Jayashakar Telangana State Agricultural University

Kenya – AMPATH; APC; DIG; KALRO; KARI; Moi University; University of Eldoret

Malawi (Trellis only) - Kusamala

Mali (Trellis only) - IPR/IFRA

Nepal - CARD-Nepal; International Development Enterprise (iDE); Nepal's District Agriculture Development Office and Agriculture Research Center; University of Agriculture and Forestry (AFU)

Tanzania - AVRDC – The World Vegetable Center

Thailand - Kasetsart University; Rhino Research/Centor Thai

Uganda - Amelioration of Agricultural Risk; Buginyanya Zonal Agricultural Research and Development Institute; Busitema University; National Semi Arid Crops Resources Research Institute; Teso Womens Development Initiative Uganda (TEWDI)

Zambia – AgriSmart; Catholic Relief Services; MAWA; Tikondane; University of Zambia

Overview of program activities, highlights, and key accomplishments

Project summary

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

FY15 performance

The Horticulture Innovation Lab began the second phase by funding major research projects focused on nutrition and gender equity. In addition, we expanded three projects from the first phase while investing in scaling three technologies. Although the projects are in their first year, Horticulture Innovation Lab researchers had a lot of success:

- We increased dry storage capacity by 1500m^3 using zeolite drying beads in novel ways in Bangladesh in just three months.
- Farmers touched by our project have applied improved management practices and technologies on 42 hectares of land, with the majority of these hectares under climate adaptive technologies such as conservation agriculture and irrigation.
- Our research projects are studying 22 different technologies and management practices that improve horticultural production.

Successes and Challenges

Successes. Horticulture Innovation Lab projects are in their first year. However, the projects are underway and proceeding on schedule. The project to scale the use of zeolite drying beads is very successful in its first year. The company that produces the drying beads is working closely with Bangladeshi seed producers to develop applications that utilize the novel things developed using drying beads (i.e. large scale seed dryers, drums to collect and dry seed, local input supply storage) to create a dry chain. We were pleased that seed companies in Bangladesh were eager to participate in this project, often providing extra funds to support expansion and scaling of the bead technologies. Additionally, our team is proud of a rapid assessment of horticulture in Guinea that was conducted and completed in the summer of 2015. Our rapid assessment provides guidance to the USAID mission in Guinea as they develop an agricultural strategy in this country that is recovering from Ebola and years of conflict.

Challenges. This year, we ran into several problems contracting to our university partners in a timely manner. This matter was resolved after our director met with UC Davis sponsored programs and developed an alternative plan that puts more control into the management entity.

Description of Expected FY2016 Activities

The Horticulture Innovation Lab will solicit for project proposals in several areas this year. We will develop a project focused on postharvest. In addition, we will solicit ideas for research projects that serve the needs of Missions.

Research program overview and structure

For the past five years, a collaborative team lead by the University of California, Davis, has managed the Horticulture Innovation Lab (formerly Horticulture CRSP), with the mission of building international partnerships for fruit and vegetable research to improve livelihoods in developing countries. Phase II of the Horticulture Innovation Lab provides an exciting opportunity to reflect on our past work and refocus our efforts for the next five years.

Rationale for horticultural research

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

Technical leadership

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

Objectives/pillars in phase II

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

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

Innovation and scaling. We work with our projects and the Regional Centers on the dissemination and scaling of innovative horticultural technologies. In addition, we have funded one project specifically focused on scaling technologies from phase I projects and are conducting research on the business case to scale two other technologies (research to by funded in FY16).

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

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

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

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

Research approach

We will issue six types of Requests for Proposals (RFPs) during Phase II, each with a different scope and focus. All RFPs will be competitive, and applications will be evaluated by a combination of Management Entity and external reviewers. Proposals must be collaborations between a U.S. university researcher and focus country partners.

In year one, we have issued RFPs for three major projects, one each for research on postharvest, nutrition, and gender equity ($1.5-$2 million each over five years). These awards were open to anyone with a PI status at a U.S. university. We funded a major research project for both nutrition and gender equity but not for postharvest because we didn't receive satisfactory proposals in that area. We also issued RFPs for scaling of phase I technologies and Spin-off Projects addressing new research needs identified by a phase I research project. Both of these RFPs were open to any PI previously funded by the Horticulture Innovation Lab.

In FY16, we will fund two additional Mission service projects on issues identified by the Missions and their value chain partners. These projects will take place in two yet to be determined countries ($300,000 over two years). Additionally, we will fund four focus projects on postharvest, marketing, food safety, production, capacity building, or mixed animal agriculture, starting in year two (four three-year projects, $375,000-$450,000 each).

Regional Centers

We fund two Regional Centers, with an increase in funding to allow each of them to hire a person dedicated to facilitating Center activities. We are working over the first three years of phase II to ensure sustainability of the Centers by the end of phase II. We have closed the Regional Center at KARI (KALRO) due to their inability to communicate, report and spend money. We are pursuing Zambia for a replacement center in Africa.

Research project reports

Theme A – Long-term research projects

Project I - Empowering women through horticulture: Honduras: Janelle Larson of The Pennsylvania State University, leads the gender project, "Women in Agriculture Network: Honduras" ($1.3 million)

Overview

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

Collaborators

- Principal Investigator: Janelle Larson, Penn State University
- Leif Jensen, Carolyn Sachs, Anouk Patel, Elsa Sanchez, Melanie Miller-Foster, and Tom Gill, Penn State University
- Arie Sanders and Adriana Hernandez Santana, the Panamerican Agricultural School, Zamorano, Honduras

Achievements

This progress report covers the first nine months (January-September 30th, 2015) of funding of the WAgN-Honduras Project (the 'project'). The project has the overall research goal to analyze how the horticultural value chain can be a mechanism to support equity and empowerment for marginalized groups. To accomplish this goal, the College of Agricultural Sciences at Pennsylvania State University (PSU) brings together a multi-disciplinary team with expertise in sociology, economics, demography, horticulture, gender and human nutrition in collaboration with a team from Zamorano University, Honduras (EAP).

Administrative: During this first nine months of funding, the contracts between UC-Davis and PSU have been signed and the subproject between PSU and EAP is in progress. The proposed

PhD position and post-doctoral position at PSU have been filled, with the inclusion of an additional PhD research assistant at no cost to the project. Two research assistants have been contracted to collect field data in Honduras and have been working closely with the PSU staff to plan these data collection trips. Four students from Zamorano University, Honduras have been identified as 2016 interns. In spring 2015, the Institutional Review Board at PSU approved the research proposal for initial focus groups and stakeholder interviews.

Initial Research: The project has four objectives/activities with the overall vision of improving women's socio-economic status and household nutrition by diversifying production to include horticulture and increase women's participation throughout the horticulture value chain (HVC). Of these specific project objectives, the critical first step is determining the barriers to women's participation in the HVC and potential barriers to technology adoption. As such, the first round of focus groups with local farmers (male and female), key informant interviews and the intra-household survey were planned for the first year. We have made substantial progress: two rounds of key informant interviews were held in February and September, and two rounds of focus groups were held in July and September.

Key informant interviews were conducted with persons linked to local organizations with the potential for future partnerships in the delivery of the project, as well as international development organizations in the same area and participants in higher levels of the value chain.

The focus groups were held in the Western Highlands region of Honduras. Various organizations were contacted to partner in organizing these workshops. These meetings served as both data collection regarding the barriers that producers face to market participation in this region, as well as initial contact with potential future collaborators.

The focus groups engaged two "social analysis systems" methodologies described in the book SAS2: A Guide to Collaborative Inquiry and Social Engagement, by Jacques M. Chevalier and Daniel J. Buckles (2008). The dynamics used were "Social Doman Analysis" and "Causal Dynamics." The goal of the social domain methodology is to "examine how people view actors and relations between them using words and characteristics that participants themselves choose and define. It also shows how people negotiate their views of actors across social and cultural boundaries. The technique may be used to test people's views against experience, solve problems, and learn in the process." (Chevalier and Buckles, 192). Causal dynamics is a method proposed to better identify the relationship between barriers by asking participants to rate the amount to which one barrier causes another. Initially, this activity was organized by soliciting from all participants in one group their limitations to participation in three categories: production; commercialization; and organization. As this was facilitated, each issue was written on a card with corresponding colors to the theme. Once the barriers were listed on cards and organized into the different categories, the group was asked to pick the two most important barriers under each heading, resulting in six barriers total.

In Table 1, we present the list of local organizations and participation split by gender. Up through September 30th, we organized 10 focus groups with a total participation of 154 persons. Three focus groups are scheduled for November 2015.

Table 1: List of organizations included in the first round of qualitative research methods

	Organization	Location	Participation		Observation
			Female	Male	
1	Asociación de Productores del Altiplano de Celaque (APROALCE)	La Mohaga, Belen Gualcho, Ocotepeque	4	8	
2	Asociación de Mujeres Intibucanas Renovadas (AMIR)	La Esperanza, Intibucá.	16	1	Women's group
3	Cooperativa Mixta de Productores del Norte de Intibucá Limitada (COMIPRONIL)	La Esperanza, Intibucá.	39	3	Two focus groups
4	Asociación de Productores de Hortalizas y Frutas de Intibucá (APRHOFI)	Santa Anita, La Esperanza, Intibucá.	1	2	Interview, focus groups in October
5	Cooperativa Regional Agroforestal Agricultores Unidos Limitada, COPRAUL	Belen, Gualcho in Ocotepeque	9	10	Two focus groups
6	Organismo Cristiano para el Desarrollo Integral, OCDI	Santa Rita, Copán Ruinas, Cabañas in Copan	5	4	
7	Asociación de Familias Agropecuarias Artesanales Intibucanas Lencas, ASOFAIL	La Esperanza, Intibucá.	12	10	Two focus groups
8	Vegetales Lencas S.A. de C.V. , VEGELESA	Sierra de La Paz Marcala, Chinacla, Santa Ana), La Paz		1	Interview; Focus groups are scheduled for November 2015
9	Unidad de Trabajadores Campesinas (UTC)	Marcala	18	11	Will not be included
		Total	104	50	154

Capacity Building

Our team created a profile sheet of each of the organizations that participated in the focus groups. From these profiles, we will identify potential future partners whose activities are linked to horticulture and/or nutrition in order to achieve our fourth objective of local capacity building. Of the total of nine organizations listed in Table 1, we have already identified a number of organizations as potential partners.

Steps planned for October 2015 – September 2016:

- Additional focus groups and stakeholder interviewers (November 2015).
- Qualitative data analysis. Further review and analysis of the qualitative data so far collected through the key stakeholder interviews and focus groups.

- Design of the household survey. Execution of this survey is currently scheduled for Spring-Summer 2016. Data entry and preliminary data analysis is planned to follow.
- Fine tuning of the network analysis for key persons in the horticulture sector (field work in the first quarter of 2016).
- Preparation of the internship of four Zamorano students (fieldwork and visit to PSU). Students are scheduled to arrive at Penn State in March 2016.
- Selection of local partners and formalizing this relationship with a Memorandum of Understanding (MOU).

Lessons Learned

While we are still in the process of analyzing the data collected during the recent field research, we can derive the following preliminary lessons learned:

- Horticulture production in Western Honduras is concentrated in four geographical areas (Intibucá, Marcala, San Marcos de Ocotepeque and Copán).
- Horticulture production organizations are dominated by men, with limited participation of women.
- Horticulture crops are mainly produced by men; women are more commonly involved in horticulture production as temporary wage laborers or as unpaid labor on their partner's land.
- Women are subject to more constraints, stemming from gender norms and other dimensions of the sociocultural domain and access/control over resources (land and credit).
- Women carry the double burden of housework and childcare responsibilities, which limit the amount of time they can devote to horticulture.
- Women have limited access to technical skills and training.

Presentations and Publications

Field reports:

Reyes, A. and H. Velasco. Las Mujeres en las Redes Agrícola en Honduras. Informe de Resultados de la Segunda Gira de Campo del 14 a 29 de septiembre.

Reyes, A. and H. Velasco. Las Mujeres en las Redes Agrícola en Honduras: Informe de Resultados de la Primera Gira de Campo del 29 de junio al 9 de julio.

Garner, Elisabeth. Women in Agriculture: Honduras Visit to Honduras. June/July 2015.

Presentations:

Poster Women in Ag Network (WAgN) Honduras. Janelle Larson, Leif Jensen, Deanna Behring, Carolyn Sachs, Anouk Patel, Elsa Sanchez, Melanie Miller-Foster, Thomas Gill, Arie Sanders, Eunice Bonsi and Elisabeth Garner. Horticulture Innovation Lab's 2015 Annual Meeting. June 8-10, 2015. Zambia.

Additional documents:

Steps to Incorporate Gender into Research and Project Design

Garner, Elisabeth. Women in Agriculture Honduras: Literature Review and Horticulture Desk Study

Project 2 – Improving nutrition with African indigenous vegetables: Kenya and Zambia: James Simon of Rutgers University, leads the nutrition project, "Improving Income and Nutrition of Smallholder Farmers in Eastern Africa using a Market Driven Approach to Enhance Value Chain Production of African Indigenous Vegetables" ($2 million)

Overview

This project's research will support and strengthen African indigenous vegetable (AIVs) industries using a market-first, science-driven approach that connects stakeholders along the value chain. The specific AIVs include but not limited to such species as amaranth, moringa, African eggplant, Ethiopian mustard, African nightshade, and spiderplant. Focus areas include greater access to quality seed and markets, improved production, postharvest handling, value addition and increased knowledge of vegetable health benefits. Value chain interventions will improve production and streamline movement of produce from farm to table while addressing food, nutrition, income insecurity, and gender inequality. Activities will characterize nutrient levels from improved germplasm, production, harvesting and postharvest handling of fresh and prepared indigenous vegetables focusing on vitamin and mineral composition, bioactive phytochemicals and anti-nutritive factors.

Surveys will track household consumption in selected areas in Kenya and Zambia examining whether diets containing African indigenous vegetables in order to assess ways to increase improve nutrition and health of targeted malnourished populations. Strategies will target smallholder farmers, wholesalers, distributors, supermarkets, hotels, lodges and urban consumers/buyers of African indigenous vegetables. Our approach will bridge information gaps through cooperation with farmer groups, consumers, government, researchers, NGOs, produce distributors, supermarkets and the processing industry while introducing creative new technologies addressing issues of food, health, nutrition and income insecurity, gender inequality as the AIV value chain is strengthened and new product commercialized. Our overall approach is to develop nutritional measures for at-risk populations and the general public to incorporate improved intake of AIVs; meanwhile, strengthening the value chain with smallholder farmers and in doing so addressing issues of: Access, Availability, Affordability and Adoption of AIVs. Both aspects of this project address major barriers to nutritional and economic growth of at risk populations in sub-Saharan Africa (SSA) that face poverty, hunger, and under-nutrition.

This project will incorporate USAID indicators to provide to the public information related to minimal dietary diversity especially for women and children, with the intention of benefitting all persons within the population in the long run.

One of the major obstacles in adequate nutrition is the availability of a diversified diet including adequate micronutrients. Some essential nutrients include: Vitamin A, thiamin, riboflavin, niacin, vitamin B6, and folate, Vitamin C, Ca, Fe and Zn. The selected AIVs with which we are working have been shown to contain good levels and in some cases high levels of most of these nutritional components. Our work will confirm levels of nutrients in fresh and processed foods containing AIVs to complement the assessment and improvement of intake of these vegetables as part of a diversified diet to meet the goals of USAID nutritional programs. In addition to these AIVs containing high levels of essential micronutrients, they are among the 10 food groups cited by USAID as targeted foods (Vitamin A rich dark green leafy vegetables, other vitamin A rich

fruits and vegetables, other vegetables) for improved human nutrition (FAO and FANTA criteria).

Our overall objectives are to understand the factors that are limiting increased consumption of AIVs, and in employing strategies involving horticulture technologies along the value chain relative to smallholder production to drive increased consumption and improve health and nutrition to deliver adequate nutrition for at risk populations of SSA. We will monitor access, availability, price, adoption, and consumption in producer households to increase consumption of nutritious foods using AIVs. Our project will address nutritional aspects of AIVs in human diets, and how through appropriate interventions in the value chain and education, from seed to consumer table, smallholder farmers involvement will help reduce poverty and food insecurity and result in improved nutrition and health for these at risk populations.

This project will then work toward identifying the most effective communication and outreach strategies to achieve these goals. We will communicate nutritional information based upon scientific research to the populace via digital filmmaking, visual images as well as more conventional radio and agricultural fairs, school demonstrations, school gardens, seed packs and development of user manuals. All these activities will impact the value chain from food production to harvesting, storage, packaging, preparation and consumption by providing important nutrient composition information for the various AIVs. Throughout the project, we will be collecting data on effects of our activities and their impacts to ensure the project approach focuses on AIV access, affordability, availability and adoption (production and increased consumption).

Collaborators

Rutgers, The State University of New Jersey is working with the following organizational partners:

- AgriSmart – Zambia
- AMPATH and Moi University – Kenya
- AVRDC – The World Vegetable Center - Tanzania
- KALRO – Kenya
- MAWA, The Catholic Relief Services- Zambia
- Purdue University – United States
- University of Eldoret – Kenya
- University of Zambia – Zambia

Achievements

Objective 1. Verify best management practices in Zambia. AgriSmart successfully developed two demonstration plots with African Indigenous Vegetables intermixed/intercropped with other vegetables in Lusaka (Mitengo and Lilayi communities) with a total of 3 hectares under drip irrigation. Mitengo group is conducting field trials on intercropping with vegetables and AIV's. Lilayi is performing variety trials on 3 different AIVs. Studies have been undertaken to promote awareness and establish baseline yield and field practices using AIVs in small-holder community commercial 'gardens'. Several trainings have been completed (proper use and handling of agro-chemicals basic, compost, drip maintenance, moringa production and grower field record keeping). One full-time female M.S. graduate student with UNZA, Zambia conducting her research and leading these field AIV studies. Two storage ponds for water saving constructed for

use in crop production (Mitengo and Luangeni). Extension material – one on record keeping for growers has been completed. In Kenya, building upon prior AIV project, AMPATH has identified farmer groups interested in producing AIVs. AMPATH has produced a production manual using information from our prior AIV project which is now being used for training farmer groups within the AMPATH catchment area.

Objective 2: Promote and expand both availability of AIVs at the local level and improve market access for producers of AIVs. The World Vegetable Center is supplying AgriSmart, KALRO and AMPATH with improved germplasm, which will be used for demonstration to farmers in intervention communities.

Objective 3. Evaluate the nutritional composition of fresh and processed AIVs. The nutritional composition of a range of AIVs has been analyzed building upon prior programs. This includes examining the vitamin (as measured by beta-carotene, vitamin E) and mineral content (e.g. Ca, Fe and Zn), and phytochemistry of: amaranth, moringa, nightshades, and spiderplant. Vitamin C is being measured at the University of Zambia. The new baseline studies being conducted in Kenya and Zambia will identify additional AIVs that will be examined for their nutritional composition. Variety trials with improved germplasm are underway in Y1 Q4 with AgriSmart Zambia in concert with the AVRDC and Rutgers to analyze across improved accessions for quantity and stability of problem micronutrients. The results from these activities will be informative toward recommended lines in intervention activities to follow. Similar field studies have been planned to be initiated in western Kenya with AMPATH to begin in January, 2016.

Objective 4: Identifying key determinants Linking Horticulture with Improved Nutrition: evaluate whether the intervention program has increased access to and consumption of AIVs among producers and consumers within select communities of Kenya and Zambia. We have conducted preliminary analysis of demographic and household survey data from World Bank for Kenya and Zambia, 1995 to present. IRB approval achieved for all planned human nutritional, consumption surveys, and grower and producer surveys to be conducted in Kenya and in parallel in Zambia. Pilot surveys defined and database created for both Kenya and Zambia. From the USA, at Rutgers there were 7 faculty, students and staff and at Purdue there was one faculty trained in Human Subjects Survey and receiving CITI certification (with 1 female, 8 males). Nutrition survey protocol defined and executed in Zambia with pilot surveys 40% completed. Nutrition survey protocol defined and will be executed in Kenya beginning November 2015. We are expecting all pilot surveys to be 100% completed by end of November 2015.

Objective 5: Build capacity of stakeholders in AIV market chain. Creation of a baseline survey for the AIV producers – 300 surveys in Zambia and 300 surveys in Kenya.

- 69 producer surveys have been completed in the Eastern Province, Zambia.
- 23 Producer surveys have been completed in Lusaka, Zambia

Creating of an intermediary survey for the AIV wholesalers/retailers/brokers – 75 surveys in Zambia and 75 surveys in Kenya.

- 50 intermediary surveys in the Eastern Province, Zambia have been completed
- 7 intermediary surveys in Lusaka, Zambia have been completed

Pre-testing of baseline producer survey as well as the intermediary survey in Zambia – surveys were tested by AgriSmart team members, feedback was received and direction provided based on

results. Development of the data entry Excel sheet for the producer survey has been completed. Work plan is being developed to pre-test and collect data in Kenya Expect to complete data collection by the end of November in both Zambia and Kenya.

Lessons Learned

The approval of IRB took far longer than expected. The ability and need to train all people implementing surveys took longer and included not only survey techniques, but training in the quality control of the data collected. The transfer of germplasm properly using all national and international forms from the USDA gene back, from the improved AIV lines which we have been working on both in Tanzania and the USA for improved traits such as improved nutrition and other horticultural traits to/from the USA to our partnering organizations in sub-Sahara Africa is taking far longer than anticipated.

Presentations and Publications

- Poster Presented at 2015 National Association of Plant Breeders Conference, Pullman, Washington
- David Byrnes, Qingli Wu, H. Rodolfo Juliani, Fekadu Dinnsa, Steve Weller, and James E. Simon. Effect of Genotype, Environment, and Genotype-Environment Interaction on Fe content of *Amaranthus* spp.
- James E Simon, Steve Weller, Dan Hoffman, Ramu Govindasamy, David Byrnes, Emil Van Wyk. African Indigenous Vegetables and their Role in Contributing Vitamins and Minerals for Improved Health and Nutrition. Presented at the Annual Horticulture Innovation Lab, Lusaka, Zambia, June 08, 2015.
- James E. Simon, invited panelist. Future Opportunities in Horticulture. Presented at the Annual Horticulture Innovation Lab, Lusaka, Zambia, June 09, 2015.
- From June 8-10, the Feed the Future-funded Horticulture Innovation Lab hosted their annual meeting in Lusaka, Zambia. The meeting included presentations by CASH project staff and Rutgers University collaborating partners (Prof. Simon and graduate student David Byrnes), and field visits to the Mitengo Women's Group and the Lilayi Innovation Center; and site visit to southern Zambia to Livingstone to tour the Mombova and Ngsongwe Women's communities.
- Completion of scientific research papers undergoing internal review:
- Hoffman, D.J., T. Cacciola, D. Byrnes, P. Barrios, and J.E. Simon. Temporal changes in nutritional status in Kenya and Zambia. To be submitted to Food and Nutrition Bulletin
- Byrnes, D., Q.L. Wu, H.R. Juliani, F. Dinssa, S. Weller and J.E. Simon. Genotype x Environment Interaction and Stability of foliar Fe, Zn, Mg, and Ca content in *Amaranthus spp.* To be submitted to Crop Science.

The following papers were written and completed during this project period, yet the field work was completed during our prior AIV Hort. Innovation Lab project:

Ayua, E., V. Mugalavai, J.E. Simon, S. Weller, P. Obura and N. Nyabinda. 2015. · Ascorbic Acid Content in Leaves of Nightshade *(Solanum spp.)* and Spider plant (*Cleome gynandra*). Varieties Grown Under Different Fertilizer Regimes in Western Kenya. African Journal of Biotechnology: (accepted and pending minor revisions, copy available).

Ayua, E., V. Mugalavai, F. Wamunga, J.E. Simon, S. Weller, P. Obura and N. Nyabinda. 2016. · Design and Performance of Mixed Modes Solar Dryer for African Indigenous Vegetable

and Chili Processing. African Journal of Biotechnology (manuscript completed under internal review prior to submission, copy available).

Croft, M., M. Marshall, S. Weller and J.E. Simon. 2016. Determinants of farmer participation in formal vs. informal AIV seed systems. (manuscript in preparation).

Croft, M., M. Marshall, S. Weller and J.E. Simon. 2016. Impact of the gender of AIV growers on measures of food security and wealth. (manuscript in preparation).

Theme B – Spin-off projects (projects based on Phase I investments)

Project I - Developing small-scale irrigation solutions: Uganda: Kate Scow of University of California, Davis, leads a spin-off project on irrigation, "Innovations in Dry Season Horticulture for Women and Smallholders in East Africa" ($300,000)

Description

This project is being implemented to develop innovations that increase smallholders', especially women's, access to irrigation for horticulture. The project had a kick off meeting earlier in the year and has just started activities in October 2015. The project's goals are to work with committees of farmers at sites where farmers are irrigating to design, test, and refine innovations. Through this participatory research, we will identify technologies and institutions that improve women's access to irrigation.

Collaborators

- University of California, Davis
- Teso Womens Development Initiative Uganda (TEWDI-Uganda)
- Busitema University
- Amelioration of Agricultural Risk
- National Semi Arid Crops Resources Research Institute
- Buginyanya Zonal Agricultural Research and Development Institute

Achievements

To date, the main achievement of the project has been to complete the process of finalizing contracts and sub-contracts and developing the working environment/staff of the main sub-contract in Uganda. The funds for project implementation in Uganda have become available in late September 2015, and the project activities are now just getting under way. In preparation for the project to run, detailed project planning has included:

1. Project Kick-Off meeting in Mbale, Uganda:
2. UC Davis & Partners individual meetings
3. Developing partnership with Innovation Lab on Small Scale Irrigation
4. Working on project activities:
    a. Identifying active farmer groups and specific locations with potential to serve as "innovation sites" for irrigation development. The project team has developed a list of potential sites that could serve as "innovation sites" in the project, and had extensive group discussion as to the criteria to be used to select these sites. These sites were compared against these criteria at a partners' meeting on October 28, where the final selected sites were selected.
    b. Developing host committees among irrigation users at each site who will be responsible for liaising between the community members and project staff. Committees are already established at 3 innovation sites that have been included in the project. The roles, responsibilities, and membership these committees' are described below.
    c. Developing operating agreements in collaboration with host committees that emphasize women's participation and voice in decision making processes. The project team has developed a first draft of an operating agreement with farmer

host-committees who will be the direct link between the project and farmers at each innovation site. A few salient features deemed important to the project team include:

i. Committees are to include 50% + female membership
ii. Members should be active irrigators with experience and respect in their communities.

d. Documenting problem-solution trees regarding irrigation access with host committee women and selected female community members. Based on previous work in irrigation communities in Uganda, the project team has developed a first mapping of irrigation challenges. This will be expanded upon to get a clearer picture of farmers' perceived challenges and potential solutions. One approach the project team is considering to develop these trees is to use qualitative interviews / focus groups to develop categories of challenges and opportunities to overcome them, and then use a quantitative survey to evaluate the validity of these problem-solution trees over the course of the project.

Capacity Building

We will train undergraduate and graduate students and build capacity of agricultural engineering/irrigation university faculty to integrate farmer-centered innovation into program. During the PI's visit to Uganda, UC Davis and Busitema University developed a framework for student involvement in the project. The items that the partners agreed to work on included

- Undergraduate internships
- Masters student project assistantships
- Scholarships for final-year student projects
- Field practicals for hands-on training

The project conducted the first field training on October 9, with 8 Busitema University students (2 masters, and 6 undergraduates). This field practical was held during installation of an irrigation system at one of the innovation sites, and gave the students hands-on training in how to install a pressurized irrigation system. Specific training activities included

- Identifying different types of pipe materials and fittings
- Laying out pipe network
- Connecting pipes and hydrants using appropriate fittings

Project 2 – Expanding tomato grafting for entrepreneurship: Honduras and Guatemala: James Nienhuis of University of Wisconsin-Madison, leads a spin-off project on tomato grafting, "Plántulas de Esperanza" ($300,000)

Description

Validate tomato grafting technology to control soil borne pathogens in Honduras and Guatemala in cooperation with women's cooperatives.

Collaborators

- Jim Nienhuis- and Erick Gutierrez - University of Wisconsin-Madison (PI)
- Monica Rodriguez and her team – Catholic Relief Services, Guatemala
- Matt Kleinhenz – The Ohio State University, Columbus, Ohio
- Julio Lopez and collaborators at the Horticulture Innovation Lab Regional Center, Zamorano, Honduras

Achievements

Prior to initiating project, Amanda Crump, Julio López and the project PI visited and consulted with the USAID mission in Honduras (Nov. 25-26, 2014) and later in Guatemala in collaboration with senior representative Mónica Rodríguez of Catholic Relief Services (July 13-15, 2015).

Erick Gutierrez from Honduras arrived to UW-Madison in May of 2015 to begin his M.S. degree in Plant Breeding and Genetics. Valeria Paz, a student from Zamorano University in Honduras, completed and internship (Feb to April, 2015) here at UW-Madison in which she did research and received training in tomato grafting technology. This was not funded by the Horticulture Innovation Lab grant, but was critical to our success.

Our team organized a successful hands-on workshop on tomato grafting and vegetable production in cooperation with Matt Kleinhenz of The Ohio State University with a total of 27 participants. The workshop was held on the campus of the University of Wisconsin-Madison with day-tours to farms, markets and agro industries in the region.

Tomato grafts were successfully produced in:

- Instituto Tecnologico de Costa Rica (in collaboration with but not paid by grant)
- Totonicapan, Guatemala in cooperation with Catholic Relief Services
- Zamorano University, Honduras where we were able to produce grafted tomato plants, critical to testing and validating this technology

Lessons Learned

- All participants, with training, some experience and a little time can learn the technology.
- Many more options for rootstock genetics exist, but we are really only able to test three with resistance to *Ralstonia* spp. as our focus.
- Initial data from a partner organization, Institution Tecnologico de Costa Rica (they are replicating the experiments at no cost to our grant) is promising. The student, Ms. Katherine Duran and her major professor, Prof. Carlos Ramirez, completed the graft

combinations and in their heavily infested soil in San Carlos, Costa Rica only the grafted plants survived.

Presentations and Publications

- Hablas plantas? CALS hosts vegetable grafting workshop in Spanish. Monday, August 24th, 2015. Online article CALS.

Project 3 - Promoting water- and labor-saving practices: Nepal and Cambodia; Manny Reyes of North Carolina Agricultural and Technical State University, leads a spin-off project, "Incentives and Markets for Vegetable Smallholders to Practice Water and Labor Saving Technologies" ($300,000)

Description

Horticulture crop production is susceptible to yield losses due to water deficiency. In regions of Cambodia and Nepal, water is scarce for extended periods, negatively affecting food security. We have been addressing this problem through labor, water and soil saving technologies (LWSST) of storing water through rainwater harvesting and by efficient water use through drip irrigation and conservation agriculture systems. We conducted experiments comparing vegetables grown in drip irrigation with conservation agriculture (CA) systems versus traditional ways farmers grow vegetables in Cambodia. Our women partners liked drip irrigation and conservation agriculture because labor in watering, tilling and weeding were reduced; vegetable yields and quality increased; they earned income; and their households can eat nutritious vegetables. LWSST can boost food security and climate change resiliency, since soil erosion can be controlled, land productivity and farmers income can be enhanced, drought can be shortened, water quality can be improved, flooding can be minimized and biodiversity bolstered. We hypothesize that for LWSST to be scaled-up, we need to: a) provide incentives to smallholders, and b) research and identify pathways for smallholders to market vegetables. We will serve marginalized smallholders who can farm only small income generating vegetable gardens of no more than 200 m^2 whose families likely suffer from chronic malnutrition. They have little training in science-based vegetable production and postharvest handling and packaging; very limited access to good seeds; and have very little capital to risk in new ways to produce vegetables. We will provide these trainings and also capital as incentives for them to shift from traditional to LWSST of drip irrigation, conservation agriculture and rainwater harvesting. They also have very limited market access. Hence, we will research and identify pathways for smallholders to market vegetables. We will work with smallholders, especially women, at Feed the Future regions in Cambodia and Nepal.

Collaborators

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

Achievements

Objective 1) To provide incentives for adoption of LWSST

Cambodia: Most women in Siem Reap commercial vegetable home gardeners (45 of them) who were involved in the first and second phase of this project through funding by the SANREM and Horticulture Innovation Labs are still producing vegetables by applying conservation agriculture and drip irrigation technologies. The incentives we provided were visits from horticulture innovation lab technicians and also seedlings. We built a seedling nursery that a cooperative will inherit. The technician recommended the best alternative may be individual single netted nurseries for each farmer and the incentive is to provide nets. We are exploring that. We are exploring the aspect of loaning these women commercial vegetable home gardeners with monies through the cooperative the project is working with. Based on our interviews, the women will

not purchase replacements of drips but they are willing to take a loan to replace drips. This is incentivizing those who are practicing to continue with the practice.

Continuous adoption of conservation agriculture is not a problem. Most commercial vegetable home gardeners like it. There challenges of continues adoption in fields that get inundated during the rainy season. Their best vegetable to produce is the wetland 'morning glory.' And these are planted very close and when harvested, the roots are pulled out. Our recommendation is to continue CA for weed and moisture control during the dry season even though the soil got disturbed by the pulling of the morning glory. We are also hearing some comments from the women home gardeners that they are having the 'conflict' of animal feed and mulch, just like the cases in Africa. Our solution this time is to maintain small plots and to encourage them to harvest the rice straw more efficiently so they can have extended mulch supply. And the third will be to grow leguminous mulch as a fence. This just buttresses the approach to go small in conservation agriculture technology, until the food producers get used to it and then we find solutions to produce mulch or to use existing mulch efficiently.

Through ADDA, we established an excellent connection of 50 women commercial vegetable home gardeners organized as a cooperative. ADDA has at least eight women agricultural cooperatives in Siem Reap and we got connected with one. We chose that site because it has all year round water supply. We talked with the women home gardeners and several volunteered to apply conservation agriculture with drip irrigation. We reached our goal of 100 commercial vegetable home gardeners by incentivizing 55 farmers (50 women and five men, most of the original 45 are continuing and those who did not continue were replaced) to practice CA with drip.

A young agricultural cooperative formed by ADDA got a boost through this project. They paid membership and also elected officers. The following was an interesting breakdown of how they handle income: 70% will be divided to cooperative members; 10% increase in capitalization for loaning to cooperative members; 7% officer honorarium; 3% training; and 10% administrative cost.

A cropping system with at least six kinds of vegetables and a cover crop was prepared for Cambodia. This is an application of sustainable intensification using CA technology. We overlapped the transplanting of vegetable seedlings while the other vegetables are still being harvested. CA does not till hence it is doable. The farmers also are learning about seedling production in the nursery, therefore they save time by sowing the next batch of seedlings (growing period in the nursery) and then transplanting these seedlings while the vegetable in the field is being harvested. Hence we anticipate having at least six kinds of vegetables. In conventional systems, women home gardeners can get at most four kinds of vegetables.

We did a business plan for the CA cropping system. From the business plan with drip and tank system depreciated, we estimated an income of $400 for each woman farmer which is 1/3 of the per capita for Cambodia. This is only for a 100 square meter area. If doubled (which some have) then that will be $800. The home gardener will be able to purchase the drip and replace the system. Cost of seeds, fertilizers and other input costs were all estimated. What was not included was labor. We assume that the woman will not hire labor and will do that herself. Hence, we always relay that this is a home garden. The plot is near or within sight of the woman's house.

Nepal: Despite of the earthquake, the Nepal iDE team was able to begin the project. It is very impressive and well done. Right after the earthquake, hoop houses funded by the Horticulture Innovation Lab in Lalitpur were used by some Nepalese families who lost their homes because of the earthquake. A summary from the iDE report: *"During this period the major focus was toward planning project activities and getting them into the ground. Significant activities include selection of sites and farmers, conducting trails and demonstration, and feasibility study for the animal built pond and water harvesting tank. So far, farmers' impression toward mulching, drip technologies and other water saving approaches has been encouraging. "*

An orientation program to all the related project staff members was conducted on May 29, 2015 at Hotel Maruti Nandan, Nepalgunj to give an project overview, approach, and expected outputs. The project sites include: a) Banke: Naubasta, b) Surkeht: Sanoharre , c)Lalitpur: Ranagaun, Lele and d) Dadeldhura: Mahargaun, Samaiji. In each site, 6 women farmers were selected for the trials.

Six smallholder female farmers (<200 m^2) from each district were selected for the field trials/demonstration. Tomatoes were the first crop planted in all those districts. In Surkhet, Lalitpur and Dadeldhura, seedlings were transplanted under the plastic tunnel house whereas in Banke tomatoes were transplanted in open fields. The treatments are: traditional system of vegetable growing, and conservation agriculture plus IPM system of vegetable growing. All treatments are drip irrigated. Yield, insect/disease and labor data will be recorded for each of the treatments.

Average production in the conservation agriculture practice was 98.75 kg in comparison with 95.07 kg in conventional practice.

Benefits from vegetable production are directly related to the labor consumption in different activity i.e. from land preparation to marketing. Farmers were found spending more time in collecting mulches i.e. 7.83 hr. on an average in conservation agriculture practice in comparison to the conventional practice. However time spent for weeding in conservation practices was 0.39 hr. compared to 4.86 hr. in conventional practices. Note the advantage of no-tillage and bed rebuilding in CA will be seen in the next crop and will likely compensate with time spent in mulching.

The average time spend of irrigation for conservation practice is less 11 hr. compared to 21 hr. in conventional practices. Mulching is believed to have played an important role.

In the conservation practice, soil insects damage was found more than the conventional practice. One of the possible explanations may be due to the fact that insects can harbor in the mulch. Similarly, much more incidence of root rot and crown rot diseases were found in conservation practices. This may be because of the higher moisture around the root region thus creating favorable environment for fungal diseases.

To build animal built rainwater harvesters, a feasibility study was done by the technical team in 3 farmers' fields. Proper location was the main criteria so that it would be able to serve large number of farmers. The team came up with two options in each of the four districts. The final selection Final selection will be done during the field visit of animal built pond expert Dr. Mercado in December 2015.

Objective 2) To identify and implement local markets and pathways to sell vegetables for continued adoption of LWSST
Cambodia: A marketing plan has been completed. A CoolBot was built by the horticulture innovation lab regional center team from Kasetsart University. The CoolBot is being managed by the agricultural cooperative. The Beng Melea Conservation Agriculture vegetable label under the agricultural cooperative has been decided on by the women home gardeners as the label of the veggies they produce. Beng Melea is a temple in the site where a lot of women home gardeners are producing veggies. This label will be put in packing materials that women will sell. Only members of the agricultural cooperative producing vegetables in CA and drip technology will be assisted in marketing veggies and can access the CoolBot.

Through the assistance of Dr. Gurbinder Gill and Dr. Angelos Deltsidis of UC Davis, the team has been meeting on how to utilize the CoolBot efficiently and how to market the veggies in the local market. Different types of marketing strategies have been planned: one targeting consumers directly and the others targeting wholesalers and restaurant owners.

A tuktuk will be purchased very soon to replace the old improvised tuktuk that the team is using for vegetable buying and marketing. The old tuktuk can only be driven by men. The new tuktuk will be specially designed so it can be driven by women. Our technician, Rechaney Sel, will start selling vegetables by November using the new tuktuk, accompanied by a woman home gardener who is a member of the agricultural cooperative. The purpose of the tuktuk is direct selling of veggies to the neighborhoods in Siem Reap. The tuktuk and the CoolBot will eventually be owned by the cooperative.

The team developed a business plan for the marketing of veggies from products of 50 farmers to be done by the agricultural cooperative. We estimated that after depreciation of the tuktuk and CoolBot and marketing costs like gas of the tuktuk and electricity for the CoolBot and labor cost of women selling veggies and many other costs that an agricultural cooperative growing veggies in CA with drip technology (all growing 100 square meter plots) will be able to earn as a cooperative about $15,000 if the cooperative markets the veggies instead of each individual farmer selling the veggies to middle persons. The cooperative can save funds to purchase the next tuktuk and CoolBot (it is incorporated in the cost). This will make this a business enterprise and will be economically and environmentally sustainable after the project ends.

Nepal: Unlike Cambodia which began in May 2013, Nepal is just starting conservation agriculture with drip technology. The plan of iDE Nepal team for this objective is italicized. The iDE team will apply their expertise in markets. iDE will look for market pathways that will enable smallholders to directly market vegetables at higher prices than marketing them through middle persons. Smallholders will be trained on proper postharvest handling and packaging of vegetables. iDE-Nepal already has a market centered approach and team will incentivize LWSST adoption by weaving in what iDE is offering.

Farmers are quite excited about the concept of mulching and are interested in replicating this practice to other crops. One of the project farmers Mrs. Sabitri Timilsina said *"Mulching practice is really good for weed management, so I will replicate it to my other plastic house from next season"*

Lessons Learned

Very good adoption of CA is happening in Cambodia and from our interviews and the practice of the women farmers participants, it appears that they are convinced in leaving the traditional methods, except for those whose fields are inundated during the wet season.

Drip irrigation may be a problem because farmers would rather spend the funds they earned in other needs than purchase a drip. This observation has also been observed in a lot of drip studies in Africa. However, in Cambodia based on some interviews, if given a loan to purchase the drip, they will likely take the loan and repay it for saving labor (difficult drudgery) when using drip. This shows that it is best to provide this option after giving a taste of the advantage of drip that was given to them earlier.

The CoolBot has an excellent potential for marketing by women vegetable producers. It is to be seen in the coming months as we use the CoolBot and tuktuk system. Hope this will be an excellent replacement for selling veggies to middle persons. It is to be noted that 60% of the agricultural cooperative's income is to be given back to the members. This will be an additional income of $180 per year per woman farmer if they sell to the consumer and not to the middle person. This can provide an incentive to the farmer to practice CA with drip. In addition, capitalization of cooperative increased by $3000. This is capital that women farmers can take a loan from to purchase drip irrigation replacements. Then, the interest from the loan will get reinvested back to the cooperative. So cooperative members win a lot from this scenario.

Presentations and Publications

- Annual Innovation Lab meeting June 2015, Zambia
- 14 Steps CA with drip: http://blog.horticulture.ucdavis.edu/2015/03/14-steps-grow-vegetables-with-conservation-ag-drip-irrigation/
- Feed the Future newsletter: http://www.feedthefuture.gov/article/conservation-agriculture-reduces-time-and-labor-women-cambodia
- FB: Conservation Agriculture for Women: https://www.facebook.com/conservationagricultureforwomen
- IFarmCA App: http://www.conservationagricultureandagroforestry.org/ifarmca/ An App to record data from CA with veggies researches worldwide.

Theme C – Scaling project (project based on Phase I investments)

Project I - Scaling and commercialization of drying technologies for improved horticultural seed and processing quality in Bangladesh led by Rhino Research

Description

The goal of this project is to create the foundation for spontaneous diffusion and large-scale adoption of advanced drying technologies in Bangladeshi agriculture. Drying in the hot, humid climate of Bangladesh, as with much of South and South East Asia, poses a significant challenge to seed production and agricultural processing. Traditional sun drying and dry room/cold storage methods lead to a rapid deterioration of the quality of agricultural outputs and especially seeds, resulting in large post-harvest losses and susceptibility to mold, fungal and insect infestations. Bangladeshi seed companies estimate that they lose 5-10% or more of their seeds due to poor drying, worth tens of millions of dollars in horticultural seeds alone. The high cost and unreliable quality of improved, high-yielding, stress-tolerant seed varieties is a major factor in why less than half of Bangladeshi farmers buy commercial horticultural seeds; an even lower share buy commercial cereal seeds. Insufficient drying of agricultural products leads to rapid deterioration after harvest and often development of aflatoxins within the products.

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

Collaborators

- Lead Institution: Rhino Research/Centor Thai
- Principal Investigator: Johan Van Asbrouck, Rhino Research, Moo Baan Sai Samphan 66/17, 66000 Phichit, Thailand, johan@rhino-research.com, Phone: +66 56 650 646, www.rhino-research.com
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Achievements

This project contributes directly and indirectly to the primary objectives of the USAID Feed the Future global strategy – reduced poverty and improved nutrition -- and is closely aligned with both the objectives and theory of change of the USAID Mission in Bangladesh. The specific aim of the project is to demonstrate the effectiveness of drying beads technology in decreasing seed and processing losses and improving quality and longevity, i.e. the business case for Dry Chain technology.

In this context, five seed companies (Lal Teer, ACI Seed, Supreme Seed, Metal Seed and BRAC), two food processing companies (PRAN and Bombay Sweets) and two organizations (DAI & CNFA) were selected for the project implementation. Project details and action plans were discussed with all participating groups trough online meetings in third week of September and overall a very encouraging response was received. However Bombay Sweets and CNFA denied joining the project due to their domestic limitations. Meanwhile Getco Agro Vision, a progressive seed company showed keen interest in the project and has been accepted by the principle investigator.

Capacity Building

I. Lal Teer Seed Limited Date: September 14, 2015

Participants:

- Dr. M.A. Razzaque (Executive Director) and Dr. M.A. Rashid (GM)

The PI gave a comprehensive presentation on the project details and action plans. Lal Teer appreciated the efforts of USAID and Rhino Research and agreed to join the project by signing in the MOU with us. Dr. Razzaque requested to give a demonstration on the 'DryStore' technology to his staff at their R&D station situated at Gazipur (Bangladesh) during the planned visit of the drying beads team in early October 2015. He also appealed to offer him one extra position for the drying and storage expert classes. Meeting adjourned with the aim to develop a strong future collaboration.

II. CNFA Date: September 14, 2015

Participant:

- Alexis Ellicott (Chief of Party) USAID Agro-Inputs Project (AIP)

The meeting was very productive. Alexis showed keen interest to participate in this project. She elucidated that CNFA is working with many agro vets and her organization is searching for the best person to be sent to the drying and storage expert classes in Thailand. Then they will be signing the MOU for participation. She was also concerned about the lack of funding to purchase the necessary products from RRG while Johan assured her that his company is accustomed to supply goods to NGOs on subsidized basis. The meeting ended up with the aim to go further in details during the next RRG staff visit to Bangladesh.

III. ACI Seed Date: September 15, 2015

Participant:

- Dr. Md. Shafiqul Aktar (Business Manager)

The PI gave a detailed presentation on drying technologies. The response of Dr. Shafiqul was highly overwhelming and he was eager to adopt the technology as soon as possible. He said that the drying beads supplied to them gave excellent results in seed drying and he claimed it as 'magic'. Further Dr. Shafiqul requested to handover one DryStore unit to his company that is already present in Bangladesh; Johan accepted his request and agreed with him to give training

to ACI staff as well during his next visit to Bangladesh. The meeting finished with the faith to develop long term collaborations.

IV. Supreme Seed Date: September 15, 2015

Participant:

- Mr. Zaker Riead (Director)

The PI gave a successful presentation on the project details and action plans. Mr. Riead was completely convinced and said that they were already looking for a good drying technology. Mr. Riead was of the view that he will be discussing our proposal with his top management and assured that they will be participating in the project by signing in the MOU during the next RRG team visit to Bangladesh.

V. Metal Seed Date: September 15, 2015

Participants:

- Engr. Sadid jamil (Managing Director) and Mr. Afzal Husain (General Manager)

The meeting was held in a very constructive environment. Engr. Sadid Jamil showed keen interest in the drying beads technology and really liked the concept of DryStore. He put some questions on the price of the drying equipment but agreed with the proposed price with 20% discount. They were totally convinced and gave positive response to sign an MOU with RR Group.

VI. DAI Date: September 16, 2015

Participant:

- Mr. Bani Amin (Deputy Chief of Party)

Mr. Bani was deeply involved in the presentation. After a successful presentation session, the PI proposed that he will be giving a special package to DAI in terms of discounts on the drying equipment. Mr. Bani said that he first wants to discuss the project details with his colleagues then they will decide the best person to be sent to Thailand for seed drying and storage expert classes. Mr. Bani mentioned that some of his colleagues were already aware of the drying beads technology and they are interested to adopt it but they want to do it in the right way. Mr. Bani was of the view that he will be consulting with his Chief of Party and will be coming back to us with right action strategy.

VII. PRAN Date: September 17, 2015

Participant:

- Mr. Naser Ahmed (Chief Operating Officer- Spices)

Mr. Naser appreciated the DryStore technology and liked the presentation of the PI. Mr. Naser was interested to adopt the technology on large scale as they have huge production of spices and other agriculture produces. Johan mentioned that you should first go for experimental basis to the mentioned drying beads technology and if you find it successful you can adopt the commercial scale equipment. Mr. Naser agreed with Johan's proposal and said that he will be discussing with his deputy managing director (Mr. Ahsan Khan) and will be coming to us to sign the MOU.

VIII. BRAC Date: September 17, 2015

Participant:

- Mr. Sudhir Chandra Nath (Program Head Seed and Agro Enterprise)

Mr. Nath admired the presentation and said technology. He described his personal experiences and mentioned that his organization procure the huge seed quantities and store them in the dehumidified rooms. They are producing the parent lines if agro and vegetable seeds while also importing the parent seeds from Australia and China. He elaborated that he wants to try the drying beads technology but alone he is unable to give the participation confirmation. He will have to discuss internally then they will be signing the MOU accordingly.

IX. Getco Agro Vision Date: September 17, 2015

Participants:

- Mr. Faukhrul Alam (Deputy Chief operating Officer) and Mr Babla (Head R&D)

Both of them were quite excited about the drying beads technology. They accepted the offer and agreed to sign the MOU. Mr. Babla will be attending the training courses in Thailand.

Lessons Learned

The project has received an overwhelming appreciation from Bangladeshi seed industry. They are keenly interested to join the project specially the seed drying and storage expert training courses in Thailand. Most of them have good knowledge in seed technology but are not well aware about the modern seed drying and storage techniques. We are committed to work hard in making them professionals in seed drying by keeping in view their available resources

Presentations and Publications

The PI delivered a presentation "Drying & Storage of Seeds- a new concept for Bangladesh with the aid of USAID Horticulture Innovation lab and Rhino Research Group" in the online meetings to the above mentioned groups. Currently, we have not published any data related to this project.

Associated research project reports (research conducted by Horticulture Innovation Lab but funded by others)

Project 1 - Improving postharvest horticulture in Bangladesh: Assessment and training: Awarded to UC Davis by DAI in Bangladesh under USAID/DAI prime contract No. AID-388-C-13-00003

Project Description

The aim of this project was to facilitate the growth and upgrading of the agricultural sector and maximize value by increasing the income for the farmers who participated in it. The resulting increased access to and availability of diverse agricultural products in local, regional, and national markets will contribute significantly to achieving improved food security in the Southern Delta of Bangladesh. A way to do this was by organizing a training which developed knowledge and skills of field staff and agronomists of the Feed the Future Bangladesh Agricultural Value Chains Project (AVC). Therefore, the project goal statement was "Improved food security through strengthened agricultural value chains".

The training was a collaboration of DAI and UC Davis and was conducted along with a site visit of UC Davis experts on postharvest practices. After a review of AVC's current report on cut flowers and a desk review of current postharvest issues in Bangladesh, the curriculum was designed in accordance to the needs identified. The course started on July 26th and for 10 days, the participants observed postharvest handling, had classroom sessions, participated in mid-course field trips to see harvest and postharvest handling practices in DAI/AVC project areas for some of the target value chains, and visits to see the postharvest technologies that have been installed in Bangladesh (CoolBot cold room and improved solar drying). The course ended with a series of intervention recommendations put together by the Innovation Lab experts and the participants of the course.

The goal of the short course was to improve the quality of postharvest training and resources for DAI field staff and their farmer beneficiaries. 25 DAI field staff were trained in pre- and postharvest practices along with 4 DAI lead staff/agronomists/extensionists at the UC Davis Postharvest Technology of Horticultural Crops Short Course in June 2015.

Collaborators

- DAI Agriculture Value Chains Project

Achievements

- Trained 30 extensionists and trainers in postharvest handing of horticultural crops.

Lessons Learned

The recommendations of the UC Davis team after the on-site visits and the experience from the course can be summarized as follows:

1) Produce quality can be high in the field, but deteriorates rapidly due to poor selection at harvest, rough handling, poor containers, and rough transportation.

2) Simple tools (picking bags, sorting tables, shade) could easily reduce some of these quality losses.
3) Returnable plastic crates, increasingly being used for more delicate products, can also provide considerable benefit in reducing damage.
4) Proper field hygiene practices such as cleaning hands and tools and equipment properly.
5) There is a near total lack of cool storage for perishables, resulting in rapid deterioration, poor sanitation, and leaves growers vulnerable to volatile markets. Provision of cooling and cool infrastructure is a challenge, but its benefits could be demonstrated first by;
    a) Deploying refrigerated containers in accumulation centers, and even using them to transport product by rail (or barge) to Dhaka.
    b) Demonstration sites with basic and low cost solar or electric coolers.
    c) Support private sector service providers to increase their use of cold storage.
6) There are few well-qualified horticulturalists researching postharvest issues in Bangladesh, developing human and institutional capacity to deal with current postharvest challenges is key to maintaining a sustainable food system. Policy level solutions include:
    a) Supporting basic research.
    b) Government supported R&D efforts through the private sector and or public institutions.
    c) Invest in laboratory facilities at research centers and universities.

Project 2 - Innovative potato storage for smallholder farmers in Bangladesh; award number LOU 16010-000-00-UC Davis-01

Project Description

The Horticulture Innovation Lab has a subaward from CIP Bangladesh to conduct a project to install and test adoption of CoolBot controlled cool rooms for storage of potatoes and vegetables in Bangladesh. The project is testing the feasibility of shared use of cool rooms by farmer communities, and the sustainability of the cool rooms, including economic assessment and maintenance issues.

Collaborators- CIP and AVRDC

Achievements

Seven cool rooms have been installed in communities with potato farmers. The rooms have been operational for various lengths of time, some for more than three years. We have successfully stored sweet potatoes until November, which had previously not been possible, and have stored seed and table potatoes for many months. When the cold room did not break down, the potato quality after storage was good and the higher price in the market would have allowed the farmers to repay the cost of the cool room in one year. With improvements in technology available in Bangladesh, the rooms are becoming more affordable. DC/inverter technology split-unit air conditioners are now available, and have the benefits of greater efficiency, and smaller start-up power requirements. This makes it cheaper to provide back-up generators or solar power.

Maintenance is still a major issue, with failures in backup generators being a major issue. We are testing local and imported generators in the expectation of identifying models that have better reliability.

Economic analysis of potential profitability of storing a range of vegetable and fruit crops show significant opportunities to use the coolrooms throughout the year to extend marketing season, and benefit from higher prices beyond the production season and during festivals and holidays.

Capacity Building

Two collaborators from CIP attended the Postharvest Technology of Horticultural Crops Short Course at UC Davis.

Lessons Learned

Availability of skilled technicians and parts, and therefore slow repairs to cool rooms, can limit the effect use of the cool rooms for storing potatoes. Ongoing electricity costs may be a barrier to sustainability of the cool rooms on electrical grid.

Project 3 - Nutrition-horticulture collaborative research program; award number AID-OAA-LA-14-00012

Project Description

Communities located in 9 unions will be utilized in Bangladesh to test three innovative technologies for improving horticulture and aquaculture productivity and value chains (3 unions per technology), to include 126 producers. The households will include producers who are not part of current or past USAID programs. Additionally, there will be many consumers of aquaculture and horticulture products in these locations who are not direct beneficiaries. Following the implementation of the first panel survey (Year 2, December 2015), the Horticulture Innovation Lab will build the three technologies; floating gardens for use on fish ponds to grow vegetables, improved solar drying technology for fish and horticultural crops, and CoolBot controlled cool rooms for storage of fish and horticultural crops.

Collaborators

- World Fish Bangladesh
- Bangladesh Agriculture University (BAU)
- Patuakhali University of Technology (PUT)

Achievements

Selection of the communities that will collaborate to test these technologies has been nearly completed. We have initiated research to determine the best technology for the floating garden, and we are collaborating with Bangladesh Agricultural University and Patuakhali University to test the solar dryer design in comparison to local designs (at BAU), and the floating garden concept (at PUT).

Capacity Building

We are working together with faculty and a student from Bangladesh Agricultural University and Patuakhali University on testing two horticultural technologies. The collaboration will help the faculty members and students learn more about these technologies and about conducting rigorous research.

Lessons Learned

Progress can be very slow in Bangladesh.

Project 4 - Advancing horticulture: Assessment of constraints to horticultural sector growth in Central America and research on rainwater harvest, drip-irrigation technologies, and conservation agriculture for vegetable smallholder farmers of Honduras and Guatemala; award number AID-OAA-LA-12-00008

Description

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. The Horticulture Innovation Lab completed an assessment of constraints to horticultural sector growth in Central America and produced a report in English and Spanish. The reports are available at: http://horticulture.ucdavis.edu/lac/.

As an applied research part of this Associate Award, the Horticulture Innovation Lab supported research on rainwater harvesting and drip irrigation technologies. This project was completed in December 2014. The research team from North Carolina A&T State University, iDE, and Zamorano University conducted an analysis of animal-built rainwater harvesting ponds in Guatemala and Honduras. Animal-built ponds are an innovative technology, especially in the steep mountainous areas of Honduras and Guatemala where it is impractical and expensive to use machinery to build ponds. Likewise, an analysis of drip irrigation was conducted.

Collaborators

- Elizabeth J. Mitcham, director, Horticulture Innovation Lab
- Alonso Gonzalez M., consultant and leader of phase I assessment
- Manuel Reyes Reyes, professor and leader of phase II irrigation/conservation agriculture research, North Carolina A&T State University

Achievements

This project was completed in the first half of FY15. The report is attached to the end of this report and was sent to the appropriate people in March 2015.

Lessons learned

We identified seven constraints to growth of the horticulture sector. Of particular importance are the need to address (1) the lack of access to research, extension, inputs and equipment to address production, pest, postharvest, and food safety problems, (2) climate volatility and climate change, especially as these relate to water and pests, and (3) the lack of market access and the facilitation of credit and insurance systems for the most vulnerable farmers, including women and indigenous peoples. The report also recommends that the region invest in initiatives to adapt horticulture to climate volatility, establish regional research programs to address cross-cutting constraints, support regional training in postharvest and food safety, and facilitate access to diverse and improved germplasm. We recommend that on a national level, efforts be made to support smallholders through crop insurance and finance programs, extension systems, and national agricultural research systems.

The recommendations from the applied research are: (1) For family nutrition, food security and supplemental income, we highly recommend investing on irrigation needs of smallholders, who grow vegetables near their homes in areas of no more than 200 m^2. (2) For reducing labor, while conserving soil and water, we highly recommend rainwater harvesting and drip irrigation combined with conservation agriculture practices for household vegetable production, with specific efforts for gender inclusion in water use decisions and crop selection. (3) In appropriate sites where the use of machinery to excavate ponds for rainwater harvesting is not feasible, we highly recommend training smallholders to build ponds with the oxen normally used for plowing and cultivation.

Project 5 – Buy-in from the Guinea USAID Mission: Rapid assessment of the horticulture sector in Guinea

Developing the horticulture sector in Guinea is an important part of improving the capacity of smallholders to grow, eat, and market fruits and vegetables. Increasing both household and commercial production, marketing, and storage of fruits and vegetables leads to diversified cropping systems, diversified diets, and greater resiliency. With funding from the U.S. Agency for International Development, the Feed the Future Innovation Lab for Collaborative Research on Horticulture (Horticulture Innovation Lab) conducted an assessment of horticulture in Southern Guinea to identify the major constraints to improving household and commercial production of fruits and vegetables. This report outlines the assessment and recommendations of activities that donors can support to address these constraints and improve the horticulture sector in Guinea.

This rapid assessment presents a snapshot of horticulture in Guinea through three on-the-ground assessments and a desk study conducted from May to September in 2015. This assessment was designed to serve as guidance for new initiatives to address constraints in the horticulture sector. The assessment detailed in this report includes considerations of farmers, institutions and markets while looking at the entire horticultural sector from seed systems to markets, with special consideration to gender and nutrition.

Our rapid assessment uncovered several interesting things about the horticulture sector in Guinea. By looking at four different Livelihood Zones and levels of wealth, we discovered that horticultural production decreased as we moved away from Conakry. We assumed that this was because of the distance away from the major metropolitan area where there is higher demand for goods, but this was just part of the story. Farmers did sell in Conakry if they could, but they also accessed well-established weekly regional markets, even if that meant traveling to a neighboring country. Farmers were motivated to sell whenever they had extra produce. Even the poorest of farmers would rent a car or ride a long distance on a bus if they thought they could access the market. This shows the resiliency and determination of the Guinean farmer. But we also know that the poorest farmers make difficult choices, often selling their staple crops to pay for expenses now only to later purchase the staple food at higher prices. So while Guinean farmers are resilient, they are also living on the margin. Our recommendations outline steps to improve the resiliency of the Guinean farmer.

When our team looked at gender divisions in horticulture production, many things surprised us. Like women all over the world, the women in Guinea grow a lot of vegetables. And like other women, they are constrained by their ability to purchase inputs and they use their profits from horticulture to pay for food and other living expenses. However, we learned that a woman's horticultural production often becomes more sophisticated when her husband's own horticultural production improves. Men also told us that they value what the women know, including what the women learn from their time in markets. Men widely reported that they adopted varieties from the women because women learn about the new varieties first.

We also learned that Guineans measure wealth based on labor and access to equipment. This coincides with their willingness to belong to groups. Whether talking to a farmer or a marketer, our surveyors found strong participation in *groupements*. These groups offer a great opportunity

for horticultural sector development through the implementation of savings groups or the creation of specialized processing and postharvest groups like the Kanya Nema.

Finally, when we looked across the horticulture sector, we discovered that great gains could be made by investing in nutrition training, postharvest processing and food preservation. Farmers who succeed at horticultural production would benefit from training in postharvest handling, packaging and storage. Consumers would benefit from having access to better stored and better processed foods. Supporting crop diversification, investing in the seed system, and scaling-up labor-saving technologies would strengthen the horticulture sector across all wealth classes, genders, and Livelihood Zones.

Summary of recommendations

A horticulture sector strategy that intentionally prioritizes rural revitalization—one that empowers individual communities to take control over their livelihoods and create their own opportunities for agricultural investment and growth—is a strategy that would find support and success in rural Guinea. In particular, we provide the following recommendations:

Horticulture sector recommendations

- *Inputs*: Facilitate access to loans or small grants and support seed production (research- or field-level) and seed banking techniques.
- *Production*: Promote simplified and sustainable farming techniques, conservation agriculture practices in horticulture, and basic fencing and animal husbandry practices to protect gardens.
- *Pest management*: Train agricultural extensionists in pest identification and provide training to farmers in the five components of integrated pest management.
- *Credit*: Create partnerships with local banks and with bankers who understand horticulture and support savings groups.
- *Entrepreneurship and marketing*: Promote the standardization and marketing of horticultural products, develop and reinforce technical exchange and support among horticulture actors, support training in basic agro-entrepreneurship skills and postharvest techniques, invest in simplified postharvest technologies, develop farmers' skills in record keeping, and conduct market research to support local agribusinesses.
- *Postharvest*: Provide training in basic postharvest practices; set up collection centers; and support smallholder processing of mango, avocado, banana, tomato and eggplant.
- *Policy*: Support the development of government policies in horticulture that create market opportunities for smallholders; support governments in setting minimum standards for the importation and sale of fertilizers, pesticides, seeds and other inputs; and provide opportunities for policy makers to attend regional workshops and conferences on creating a competitive, private sector-led fertilizer and input industry.
- *Nutrition*: Support interventions in household gardening along with nutrition counseling, education and behavior change communication; and take a broad, community-level approach to nutrition

Support for particular crops

- *Chili pepper*: Develop a seed marketing initiative, provide training in good agricultural practices (GAPs), build linkages between growers and international markets, and improve the processing.

- *Okra*: Increase support of production and drying.
- *Eggplant*: Improve irrigation for dry-season production, improve the quality and availability of fertilizers in local markets, and support research on better production and postharvest practices.
- *Tomato*: Support research and testing of new varieties and pest management strategies; develop Guinean institutional capacity to design and implement GAPs for tomato; and invest in postharvest interventions of shade, packaging, and processing.
- *Mango*: Support integrated pest management strategies for fruit flies, facilitate the dissemination of improved varieties, and invest in postharvest handling and storage and processing.
- *Oranges*: Support research in pests of oranges and orange trees.

Recommendations for women farmers

- Improve upon traditional drying methods
- Encourage the production of fruits and vegetables by men and women alike to capitalize on the advantages that each provide to the other.

Recommendations by wealth quartile

- *For wealthier growers*: Invest in postharvest education and production technologies; and introduce conservation of products through juicing, canning, pulping and freezing.
- For middle-income growers: Provide training in postharvest skills and postharvest technologies.
- *For poor growers*: Support training and research in production; assess time and labor allocations for these farmers and design approaches based on those; and provide basic training on home gardens and nutrition.
- *For poorest growers*: Conduct training programs with a goal of improving basic production, improve access to inputs, introduce home gardening where it doesn't exist, and create improved access to social safety nets.

Recommendations for human and institutional capacity development

- Develop the extension system in Guinea through strengthening the national extension system, *Direction Nationale d'Agriculture*, and investing in extensionists.

Recommendation by Livelihood Zone

- *Zone GN02 (Piedmont Zone)*: Take a value chain development approach that focuses on postharvest management, improved postharvest technologies, building market linkages and organizational development.
- *Zone GN 03 (Central Plateau zone)*: Improve postharvest handling and packaging.
- *Zone GN 09 (Wooded Savannah Zone)*: Focus on diversification and introduction of improved varieties and cropping diversity; support this zone in becoming a hub of seed production; and support crop diversification, technical training, organizational development, introduction of new and/or adapted crop varieties and facilitating commercialization.
- *Zone GN 10 (Pre-Forest Zone)*: Initiate and support crop diversification opportunities and small scale irrigation, provide training on seed production and conservation, promote

appropriate postharvest technologies and management, improve upon traditional drying methods, and scale-up labor-saving production methods.

The complete report is included as an appendix to this report.

Special initiatives

Initiative 1 - Regional Centers of Innovation

Regional Center of Innovation at Kasetsart University

Description

Horticulture Innovation Lab Regional Center at Kasetsart University has worked on several activities with various partners to disseminate horticulture technologies to Feed the Future countries in Asia, including Nepal, Bangladesh and Cambodia. The activities ranged from evaluating, adapting, and demonstrating technologies to conducting training programs. The new and exciting developments include:

- Progress on possible dual/joint 'climate change and food security' MSc curriculum with several leading agriculture universities in ASEAN (University of Putra Malaysia, Bogor Agricultural University, Gadjah Mada University, and University of the Philippines at Los Banos). This new MSc degree will enable more collaboration on horticulture technology innovation especially for tropical regions.
- The opportunity for the Regional Center to join a project 'Feed the Future Asia Innovative Farmers Activity' with Winrock International. This USAID funded project targets food security, poverty reduction, and improved nutrition and horticulture innovation will be one of the key components.

Collaborators:

- Bangladesh: DAI, Bangladesh
- Cambodia: Royal University of Agriculture (RUA), Phnom Penh, Cambodia
- Nepal: University of Agriculture and Forestry (AFU), Chitwan, Nepal and Nepal's District Agriculture Development Office and Agriculture Research Center, Nepal

Achievements

- The center has conducted short term training, transferring knowledge and technologies to more than 160 individuals (125 male 35 female). The trainings have been focused on Feed the future countries (Bangladesh, Cambodia, Nepal) and we also trained participants from 10 other countries.
- We developed 2 research projects to increase the probability to use our technologies properly. The first project is to develop the cool room usage monitoring system; this system will record the use of electricity and behavior of the farmers using cool room and record automatically for improving the usage efficiency. The second project is to find the suitable condition for long term seed storage for Thai vegetables.
- We setup space for the center in Bangkhen campus. This center is located in Department of Horticulture so visitors can visit easily. The horticulture students also use technologies for their study and research. We also maintain center technologies in Kampang Saen Campus and provide labor and upkeep the demonstration fields and infrastructure.
- We success to introduce low cost cool room and CoolBot system to farmer community in Siem Reap, Cambodia. Farmers already started using the cool room to store their vegetables and change the way to sell them in bigger lot for better price. The local trainer is also monitoring the power consumption of the cool room so they can calculate cost of their produce.

- The D-Lab course has been very successful for teaching students the concept of the innovation process. All projects have built complete prototypes. The solar dryer was testing the performance for drying whole bamboo shoot and pandan leaves. The young coconut shell opener is working well to crack coconut shell in circle shape and use the spoon to open the fruit for drinking coconut juice and coconut meat. The low cost vacuum seal uses a second hand refrigeration compressor as the vacuum pump and a electric hot wire seal. The cold room project is designed and built.
- The center developed 2 research projects;
    - Cool room usage monitoring system. Using a cool room to store vegetables can help farmers keep their produce fresh and can sell it in a better price. But the cool room itself uses electricity that raises cost of the produce. Learning the environmental condition surrounding cool room and behavior of using it such as the frequency of opening and closing door, duration of door opening and the cooling time of the produce will help them improve power efficiency and safe cost. This monitoring system composes of several sensors measuring temperature and air humidity inside and outside the room, power consumption, and door opening sensor. A datalogger will record the use of electricity and behavior of the farmers using their cool room and record automatically for improving the usage efficiency.
    - The suitable condition for long term seed storage for Thai vegetables. Cool room can be used for seed storage. Many new horticulture crops have been introduced to farmers and proper seed storage method will increase germination rate and growth of seedling. This experiment will compare 2 storage methods, normal sealing package and vacuum package. Red been seeds will be stored at 10^{o}C for 1 year and then brought out to test the germination rate.

<u>Capacity Building</u>
Additional trainees (from non-Feed the Future countries, with leveraged funds)

- Indonesia Male 3, Female 2
- Iraq Male 1, Female 0
- Jordan Male 1, Female 0
- Lao Male 2, Female 0
- Myanmar Male 3, Female 0
- Nigeria Male 1, Female 0
- Pakistan Male 1, Female 0
- Sri Lanka Male 0, Female 1
- Sudan Male 1, Female 0
- Switzerland Male 1, Female 0

Regional Center of Innovation at Zamorano University

Description

The Regional Center of Innovation at Zamorano promotes agricultural production to a sustainable level for the small and medium producers through the use of low cost technologies, programs of vocational training, opportunities for the diversification of family income and the food and nutritional security.

Collaborators:

UC Davis, University of Wisconsin Madison, Honduran Ministry of Agriculture and Livestock, the Guatemalan Ministry of Agriculture, USDA Regional Mission, Counterpart International, iDE Honduras, MásRiego Project Guatemala.

Achievements

- The Regional Center has achieved the establishment of 15 different technologies with an approach in production, post-harvest and added value doing emphasis in the topic of climate change. The Regional Center has achieved the establishment of 15 different technologies with an approach in production, postharvest and added value doing emphasis in the topic of climate change, this technologies has adjusted for small producers and with this, we have managed to assure that they are producing their own food and we are strengthening their food safety.
- In one year we have achieved the training of approximately 650 people, between technical personnel, promoters and producers of different companies and institutions in topics of production, post-harvest, integrated management of plagues, integrated management of cultures, climate change, good agricultural practices, food safety and food Security.
- It has been achieved the increase of visitors by private institutions, non-governmental organization and other academic institutions, for example CISA Nicaragua exporters, Kolping project, American Embassy, Yale School and other authorities like Dr. Jeffrey Lansdale, Zamorano Rector, Krysta Harden, United State Department of Agriculture USDA, Jacobo Paz Minister of Agriculture and Livestock.
- It has been accomplished the establishment of Module of Management of Crops and Climate Change for senior students of the different undergraduate programs, in which, since 2012 to date, 800 students have taken the Module.
- It has been established the interaction and union of the four Zamorano careers and the development of investigation projects for the students. This year we made five project investigations.
- It has been promoted and accomplished the development of the compromise with the social university responsibility under the interaction of senior student's in the module of MIC- CC.
- It has been completed the integration of other projects under the Regional Center, in which 47 families of rural areas were benefit, 424 technicians, promoters and students with funds of different institutions and universities, like North Carolina University, Kolping Project, SNV Nicaragua and Ohio State University were trained
- Technologies have adjusted for small producers and with this, we have managed to assure that they are producing their own food and we are strengthening their food safety.
- In one year, we have achieved the training of approximately 650 people, between technical personnel, promoters and producers of different companies and institutions in

topics of production, post-harvest, integrated management of plagues, integrated management of cultures, climate change, good agricultural practices, food safety and food security.

Additional Achievements

Establishment of crops in open field

All crops established in this area, have been established by people who work in the center and students from the module MIC-CC and Soil conservation. Bio intensive Garden improves the availability and diversity of foods for consumption in order to improve household nutrition. Some of the established crops are: Sweet potatoes, beans, carrots, lettuce, cabbage, beet, yam, cucumber, onion and celery.

Establishment of crops under structure

The Center has different structures, mesh structure and macro tunnel with antivirus mesh. The mesh structure is a permanent protective structure for the crop. This is a highly recommended solution for intensive production of high value commercial crops. The macro tunnel is a mobile structure that protects plants for the duration of the lifecycle. It is an alternative solution that protects against insect damage to susceptive plants. Some of the established crops are: hot pepper, tomatoes, chives, pepper and onion.

Establishment of New Technologies

The centers have new technologies established in this year:

- Solar dryer
- Zero Energy cool chamber
- Charcoal Cooler
- Hydroponic System
- Technology for water harvesting and use in crop irrigation

Students in the module MIC-CC

In this module the students know about new practices for growing vegetables, fruit and basic grains that are used in integrated pest and crop management practices, practices for adaptation to climate change, post-harvest for vegetables and fruits and propose innovative management plans.

Capacity Building

The regional center is building the capacity of local NGOs and extensionists by providing training and mentorship to trainers. The closer we work with Zamorano the more we are able to learn from each other about our institutional practices and are able to share new methods and processes to more effectively implement our projects

Initiative 2 - Trellis Fund

Description

The Horticulture Innovation Lab's Trellis Fund provides small-scale, in-country development organizations access to U.S. graduate student expertise, providing benefit to both the student and the in-country institutions. Trellis Fund projects address a variety of horticultural development topics, including irrigation, fertilization, other aspects of production, pest management, postharvest practices, nutrition, or marketing issues in relation to fruits, vegetables and high-value horticultural crops. This year, 5 "concept note" projects (CN) were funded in which a graduate student worked with an organization on a project development stage before submitting a "technical project" proposal (T) for potential funding.

Collaborators:

Bangladesh:

- Palash Chandra Torfder, PRIDE (CN); Student: Brittany Pierce, University of California, Davis

Ethiopia:

- Yared Getaneh, SANRM (CN); Student: Emily Gousen, University of California, Davis

Ghana:

- Hussein Alhassan, KayFund (CN); Student: Dev Paudel, University of Florida
- Samuel Owusu-Takyi, KITA (T); Student: Jason Tsichlis, University of California, Davis
- Sena Ahiabor, Tip Top Foods Ltd. (CN); Student: Gabriel LaHue, University of California, Davis

Guatemala:

- Karen Castillo, ILAG (CN); Student: Brandon Louie, University of California, Davis

Kenya:

- Raphael Makokha Otakwa, APC (T); Student: Weiyuan Zhu, University of California, Davis
- Noah Derman and Olivia Nyaidho, DIG (T); Student: Belinda Richardson, University of California, Davis
- Johnson O. Nyasani, KARI (T); Student: Hung Doan, University of California, Davis

Malawi:

- Tiffany Loveridge, Kusamala (T); Student: Deirdre Griffin, University of California, Davis

Mali:

- Sokona Dagnoko, IPR/IFRA (T); Student: Mark Felice, University of California, Davis

Nepal:

- Jhalendra Rijal, CARD-Nepal (T); Student: Samuel McGowen, North Carolina State University

Thailand:

- Dr. Jingtair Siriphanich, Dr. Kietsuda Luangwilai, & Dr. Apita Bunsiri, Kasetsart University (T); Student: Macarena Farcuh, University of California, Davis

Zambia:

- Elke Kroeger-Radcliffe, Tikondane (T); Student: Miguel Macias González, University of California, Davis

Achievements

In 2014-2015, Trellis involved 14 graduate students from 3 universities (UC Davis, University of Florida, and North Carolina State University). Students worked with partner organizations in 9 countries. Projects ranged from training farmers in postharvest handling and processing, to providing soil science workshops and testing, to promoting sweet potato production. Trellis projects trained 1082 farmers (646 of which are women).

The 2014 Trellis year launched the first Concept Notes (CN), 5 projects that first went through a proposal development process with students, before potentially being funded as full Technical (T) projects. Four of these projects have moved onto the technical stage.

Capacity Building

In 2014-2015, Trellis trained 1082 farmers (60% women). In addition, 14 US graduate students received training on agricultural development, workshop facilitation, gender empowerment, and more. For the Concept Note projects, the 5 graduate students also trained members of their organization in grant writing and project design, totaling 22 people (7 women).

Lessons Learned

The contract and grant disbursement took longer than expected, which caused concerns from organizations and often placed students in an awkward middleman position. As a result, the new timeline for the next round of Trellis will finalize contracts with the organization before matching students to projects.

In the 2014-15 Trellis round, we experienced challenges in communication with the organizations. In future Trellis rounds, we would like to build a better working relationship with organizations and the people in them. We will plan to be much more involved with the funded organizations from the beginning, providing support and guidance, long before they are matched with a graduate student, so as to avoid the student being seen as the liaison between Trellis and the organization. In order to do this we need to do a better job of communicating with them regularly to make sure everyone is on the same page about what the students role is, what Trellis' role is, and what we expect from them.

This last year there were also a number of security concerns for students traveling to certain countries. In response we developed a standardized emergency preparedness plan, including having all students fill out and sign a Memorandum of Understanding (MOU). We also implemented a procedure where a Trellis coordinator review the country report for their destination country before they sign their MOU, so that the student is fully aware of the risks, as well as the resources they can access if necessary. Trellis also developed an emergency plan for what we need to do as an organization to ensure the safety of all our travelers.

We had great success with recording trainings, which was well received, not just by the students at other universities but also by people at Davis. We would like to capitalize on this success by expanding the trainings into a Trellis class.

Due to the high turnover of Trellis Fund coordinators, as a result of it being run by graduate students, and given the many changes that have been made this last round, we created a Trellis Coordinator Manual (TCM) to ensure that this institutional learning was not lost. The goal is that the TCM will be continually updated to reflect any future changes and lessons learned.

Finally, we would like to improve our organization and student scoring systems to streamline application review.

Human and institutional capacity development

Short – term training

Country and title of training	Purpose	Training institution or mechanism	Home institution	Men trained	Women trained
Zambia					
CITI Certification for Human Subject Research	To certify in human subject research	University of Miami course/testing presented by Rutgers University for training of AgriSmart personnel who will be involved in data collection.	n/a	7	9
Bangladesh					
Postharvest training with DAI	Train extensionists in postharvest	UC Davis and Kasetsart University	n/a	28	2
Cambodia					
Introduction to cool room and profit from cold storage, train how to build cool room	Coolroom design and installation	Kasetsart University	RUA	13	5
AVRDC training	Horticulture production and technologies	Kasetsart University	n/a	8	4
Nepal					
Introduction to cool room and profit from cold storage, introduce Horticulture Innovation Lab technologies, define postharvest problem and provide solutions.	Postharvest handing	Kasetsart	Agriculture and forestry University, Chitawan	108	30

Country and title of training	Purpose	Training institution or mechanism	Home institution	Men trained	Women trained
Rainwater harvesting and drip irrigation	Rainwater harvesting and drip irrigation	iDE Nepal	iDE Nepal farmers	183	77
Thailand					
D-Lab course	D-Lab course	Kasetsart	n/a	Total 30?	
AVRDC training	Horticulture production and technologies	Kasetsart University	n/a	17	4
Honduras					
Tomato grafting	tomato grafting during an 8 week internship at	the Univ. of Wisconsin – Madison Hands-on, applied research done in the greenhouse	Zamorano	0	3
Counterpart extension certification group	Horticulture technologies	Zamorano	Counterpart Guatemala	70	6
Training of Biological control, weed management and IPM	Biological control, weed management and IPM	Zamorano	n/a	15	3
Postharvest short course	Postharvest handing of fruits and vegetables	Zamorano	Variety of local and regional institutions	20	7
Training of trainers	Farmer field school	Zamorano	n/a	30	10
Communication Techniques for internal and external point of view	n/a	Zamorano	n/a	20	6
Soil interpretation and analysis	n/a	Zamorano	n/a	15	2
Local leadership course	n/a	Zamorano	n/a	1	23
Extension and rural communication	n/a	Zamorano	n/a	1	27

Country and title of training	Purpose	Training institution or mechanism	Home institution	Men trained	Women trained
International week of soils	Congress event	Zamorano	n/a	74	320
Costa Rica					
Tomato grafting	tomato grafting during an 8 week internship at	the Univ. of Wisconsin – Madison Hands-on, applied research done in the greenhouse	Univ. of Wisconsin and later at Instituto Tecnologico de Costa Rica	13	5
Guatemala					
Tomato grafting	tomato grafting during an 8 week internship at	the Univ. of Wisconsin – Madison Hands-on, applied research done in the greenhouse	Zamorano	0	3
Uganda					
Irrigation	Hands-on training for irrigation engineering students	In-field practical	n/a	7	1

Long-term training

Name	Sex	University	Degree	Major	Graduation Date (month/year)	Home Country
Erick Gutierrez Benites	M	Univ. of Wisconsin-Madison	M.S.	Plant Breeding and Genetics	Sept. 2017	Honduras
David Byrnes	M	Rutgers, The State University of New Jersey	Ph.D.	Plant Biology –plant breeding for improved nutrition	TBD	USA
Inonge Siziya	F	University of Zambia (UNZA)	M.S.	Plant Science-horticulture	TBD	Zambia
Arianne Vasitalis	F	Rutgers, The State University of New Jersey	Ph.D.	Plant Biology-natural Products and nutrition	TBD	USA
Bo Yuan	M	Rutgers, The State University of New Jersey	M.S.	Food Science	TBD	China
Paige Castellanos	F	PSU	Post-doc	Rural Sociology	Aug 2016	USA
Elisabeth Garner	F	PSU	Ph.D.	Rural Sociology	Aug 2017	USA
Arie Sanders	M	EAP/PSU	Ph.D.	Rural Sociology	Aug 2018	Honduras (Netherlands)
Pisey Sar	F	Royal University of Agriculture, Cambodia	B.S.	Agronomy	December 2015	Cambodia
Siv Ee Tong	F	Royal University of Agriculture, Cambodia	B.S.	Agronomy	December 2015	Cambodia
Vihul Moeurn	M	Royal University of Agriculture, Cambodia	B.S.	Agronomy	December 2015	Cambodia
Elyssa Lewis	F	University of California, Davis	M.S.	International Agricultural Development	September 2016	USA (South Africa)

Name	Sex	University	Degree	Major	Graduation Date (month/year)	Home Country
Namho Kim	M	University of California, Davis	M.S.	International Agricultural Development	June 2015	South Korea
Emily Baker	F	University of California, Davis	M.S.	International Agricultural Development	June 2015	USA
Liz Hohenberger	F	University of California, Davis	M.S.	International Agricultural Development	December 2016	USA
Azia Hasan	F	University of California, Davis	B.S.	American Studies	September 2015	USA
Anthony Phan	M	University of California, Davis	B.S.	Chemistry	TBD	USA
Elise Brockett	F	University of California, Davis	B.S.	International Agricultural Development	TBD	USA
Gianina Martynn	F	University of California, Davis	B.S.	International Agricultural Development	TBD	USA
Owen Cortner	M	University of California, Davis	M.S.	International Agricultural Development	December 2015	USA
Emily Kovar	F	University of California, Davis	B.S.	International Agricultural Development	TBD	USA
Robert Duggan	M	University of California, Davis	B.S.	Computer Science	August 2015	USA
Mariah Cosand	F	University of California, Davis	M.S.	International Agricultural Development	TBD	USA
Jason Tsichlis	M	University of California, Davis	M.S.	International Agricultural Development	September 2015	USA
Kelsey Barale	F	University of California, Davis	M.S.	International Agricultural Development	December 2014	USA

Institutional development implemented by the research projects

- Rutgers University and Purdue University worked closely with the progenitors of AgriSmart in 2015 to assist in the formation of this new fully registered NGO in Zambia to focus. This was accomplished; AgriSmart is fully functioning NGO in Zambia which will be the implementing partner in Zambia.
- University of Wisconsin-Madison developed a good working relationship both Catholic Relief Services in Guatemala as well as the Horticulture Innovation Lab director and staff at Zamorano, Honduras
- The Regional Center at Zamorano is building the capacity of local NGOs and extensionists by providing training and mentorship to trainers. The closer they work with Zamorano the more the partners are able to learn from each other about institutional practices and are able to share new methods and processes to more effectively implement projects.

Technology transfer and scaling partnerships by projects

Project: Improving nutrition with African indigenous vegetables

1) Steps taken
   a) Prepared Subcontracts and subagreements with all consortium parnters;
   b) Visited partnering organizations in Zambia: Simon worked with Zambian partners in March/April; then Simon, Weller and Byrnes worked with Zambian partners in May/June linked with annual Hort. Innovation Lab in Zambia, June 2015; then Simon worked with Zambian partners in October, 2015; and Byrnes and Govindasamy worked with Zambian partners in October/November, 2015
   c) Visited partnering organizations in Kenya: Byrnes, Govindasamy and Hoffman working with Kenyan partners in October/November, 2015.
2) Partnerships made
   a) Purdue was issued and has a fully executed subcontract a subcontract with Rutgers University for Y1 work; subject to renewal;
   b) AgriSmart was issued and has a fully executed subcontract a subcontract with Rutgers University for Y1 work; subject to renewal;
   c) AVRDC was issued and has a fully executed subcontract a subcontract with Rutgers University for Y1 work; subject to renewal;
   d) Moi University/AMPATH was issued and has a fully executed subcontract with Rutgers University for Y1 work, subject to renewal;
   e) AgriSmart issued a subagreement to KALRO, which has been reviewed by KALRO-West and now being reviewed for signature by KALRO, Nairobi. Funds for survey work to KALRO being routed through AgriSmart. Rutgers assisted in drafting the subagreement;
   f) Rutgers University and the University of Zambia now in process of negotiating an MOU (work between Rutgers and UNZA is ongoing but MOU could further strengthen the linkages and collaborative projects); and
   g) AgriSmart and the University of Zambia now in process of finalizing an MOU (while work between AgriSmart and UNZA is ongoing in support of this HortNutrition project).
3) Technologies transferred
   a) New studies on moringa to include intercropping was transferred to the Mitengo Womens community;
   b) Two storage ponds constructed for water saving at sites Mitengo and Luangeni with AgriSmart Zambia;
4) Technologies scaled
   a) None yet
5) Technologies ready to scale
   a) None yet

Project: *Plantulas de Esperanza*

1) Steps taken- hands on workshop at University of Wisconsin - Madison
2) Partnerships made- Catholic Relief Services – Guatemala, Horticulture Innovation Lab Regional Center Zamorano– Honduras, Matt Kleinhenz – The Ohio State University
3) Technologies transferred- Tomato grafting technology and germplasm
4) Technologies scaled – N/A
5) Technologies ready to scale- N/A

Project: Scaling and commercialization of drying technologies for improved horticultural seed and processing quality

1) Steps taken- Major seed companies, processing groups and NGOs have been approached, project details and action plans were discussed with them. A comprehensive MOU was drafted and shared with all the participating organizations; and utmost efforts were made to take them onboard for said project.
2) Partnerships made- Successful partnerships have been developed with Lal Teer, ACI Seed, Supreme Seed, Metal Seed and Getco Agro Vision in the form of MOUs while BRAC, PRAN and DAI will be joining this venture very soon
3) Technologies transferred- Currently, the project is on the very initial stage so no technology has been transferred yet.
4) Technologies scaled- Drying beads, DryBox and DryStore technologies have been scaled.
5) Technologies ready to scale- The FlexiDry and QualiDry technologies are in the pipeline of scaling up.

Environmental management and mitigation plan (EMMP)

Per recent guidance from USAID, the Horticulture Innovation Lab will be developing and reporting against a detailed environmental management and mitigation plan. We have appointed a committee of three Management Entity members to review the ADS, USAID policies, our IEE, and the projects that we have funded. This review will result in an environmental management and mitigation plan that will be vetted by the Horticulture Innovation Lab AOR and reported against in the FY16 annual report.

Open data management plan

In August 2015, the Horticulture Innovation Lab submitted our open data management plan to our AOR. We have not received feedback on that plan but are proceeding with it. The plan is included as an appendix to this report. The first thing to be uploaded to the DDL is going to be the data from the rapid assessment in Guinea. This will be done in FY16.

Governance and Management Entity activity

The extensive horticulture experience UC Davis and the Management Entity bring to the management of the Horticulture Innovation Lab is of tremendous value to this program and to USAID. Our team uses this expertise to develop strategic plans for promoting the benefits of horticultural crop production and marketing to improve livelihoods in developing countries. With this expertise, we develop RFPs and lead the evaluation of proposed research activities. The ability to rely on a management team with extensive expertise in a particular field to manage the research portfolio is one of the great strengths of the Innovation Labs for Collaborative Research.

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

A unique feature of our management team is that many of our leaders devote only part of their professional time to our program. For this reason, we have a large management team, but the total management FTE is comparable to similar programs. Responsibilities of each individual are matched to their interests and experience as much as possible. This year, to fill a need, we hired an international postharvest specialist part-time to work on projects that have been given to the Horticulture Innovation Lab by other entities. During FY15, we worked hard as a team to learn from projects that we funded in phase I and sought to incorporate the lessons we learned into the new research projects.

Other topics

Other topic 1 - D- Lab at UC Davis

Description

This project will build on the 2012-2014 activities with the UC Davis D-Lab and the Horticulture Innovation Lab Regional Centers in Thailand and Honduras. Based on lessons learned during that period and current needs, this project focuses on:

- Supporting the satellite D-Labs at the two regional innovation centers. The objective will be to provide technical and curriculum support to improve implementation of the D-Lab course, including more horticulturally appropriate technologies.
- Assisting Zamorano University with the process to become an officially sanctioned D-Lab.
- Promoting the Cool-Bot technology through technology and business development, modeling, and pilot project design.
- Develop spreadsheet/calculator from Uganda Cool-Bot analysis that can be used to enter local information (electricity rates, costs of components, market figures) to determine the feasibility and profitability of the Cool-Bot Cool Rooms
- Collaborate with Horticulture Innovation Lab and its partners to test the spreadsheet/ calculator in Tanzania
- Assist the Horticulture Innovation Lab with a low-cost insulation demonstration at UC Davis Center

In addition to the specific activities above, the UC Davis D-Lab will continue to assist the Horticulture Innovation Lab in assessing, promoting, and augmenting the current portfolio of horticulture technologies. They will also collaborate, network, and share information with the regional innovation centers and other partners.

Collaborators

Kasetsart University and Zamorano University

Achievements

Objective 1. Provide technical and curriculum support to improve implementation of the D-Lab course, with an emphasis on horticulture-focused appropriate technologies, at Honduras and Thailand Regional Centers.

- Feasibility Studies Curriculum to be presented on site visit to Cambodia and/or Thailand has been drafted. We have worked collaboratively with Kasetsart University to draft feasibility studies module for them as well as identify appropriate times in the year to visit.

Objective 2. Assist Zamorano University with the process to become an officially sanctioned D-Lab.

- The appropriate pathway for D-Lab Zamorano to become a recognized D-Lab and become part of the International Development Innovation Network (IDIN) is for the instructor and others at the school to attend a design summit (IDDS) so the school can benefit from the wide range of innovators and projects on future collaborations, as well as obtain access to microgrants for projects. Zamorano and its D-Lab can then become a potential host for future summits, and the D-Lab at Zamorano can evolve into a regional innovation center. We are working to find key people to send to IDDS in the following year. So far two people connected to the D-Lab have been identified; Ivana Vejerano and Jose Miguel Holguín, instructors who collaborate with D-Lab. However, D-Lab

Zamorano's future instructor, to be hired starting January 2016, will be the most important person to attend a summit.

Objective 3. Promote the CoolBot technology through technology and business development, modeling, and pilot project design.

- The Beta version of the CoolBot calculator was completed and initial tests have been done. Communication has been maintained with Siwalak from Kasetsart University to put together a CoolBot based Feasibility Study for D-Lab 1 in the Winter Quarter of 2015.

Objective 4 Assist the Horticulture Innovation Lab in assessing, promoting, and augmenting the current portfolio of horticulture technologies.

- Ongoing

Lessons Learned:

Getting in touch with and talking to Siwalak has presented some challenges which have been resolved using the chat application LINE.

Other topics 2 – Monitoring and evaluation

The Horticulture Innovation Lab monitoring and evaluation plan is attached as an appendix. It outlines our process to assess the impact of previously and currently funded projects in addition to the annual monitoring that we conduct. The Horticulture Innovation lab hired an external evaluator for FY15 in addition to a student focused on monitoring and evaluation. In FY15, they conducted reviews of projects in Tanzania and Zambia.

Other topics 3 – Progress towards overall phase 2 objectives

Objective/pillar 1 – Collaborative value chain research

In this phase, we have solicited for research proposals that address critical gaps in knowledge along the horticultural value chain. We have invested in two five-year research projects on gender equity and nutrition which will position us as thought-leaders in these aspects of horticulture. We have invested in supporting continued research from former projects and in the scaling of technologies.

As we look forward to the remaining projects that will be funded by the Horticulture Innovation Lab, we will aim to fill in research gaps that have not been met by projects in the last six years.

Objective/pillar 2 - Approach to innovation and scaling

Considerable effort has been placed on better positioning Horticulture Innovation Lab projects for success in scaling. Activities have involved two phases of focus. Firstly, working closely on both technical and economic evaluation from the early stages of projects and then working on a more detailed scaling analysis for more mature projects.

The Horticulture Innovation Lab initiated an activity to identify key factors related to the extent to which technologies are likely to spread more widely. The activity identified factors related to the practicality of project technologies and factors to consider for wider success. The initial criteria considered included:

- Relevance - Potentially, what percent of farmers in developing countries will be interested in the technology
- Practicability - Potentially, what percent of farmers can readily test and do something with the technology
- Applicability - Potentially, what percent of regions of the developing world can benefit from the technology
- Deliverable Quality – Does enough information on technology exist to be successful? What is the novel information?

These factors were then expanded to develop a technology evaluation sheet (involving both technical and economic elements). This sheet helps PIs consider their technologies beyond research – consider factors of practicality and economics. The sheets were pre-tested with various researchers in the group and will form the basis for on-going analysis.

A focused workshop allows the technology development team to place their technology into a wider context. Observations using the framework of information and questions outlined in section “i) steps taken” emerged with example observations as detailed below. Note that observations are related to the technology and the value chain and potential stakeholders:

Efforts for enhanced scaling of two mature projects have involved engagement with Richard Kohl. Mr Kohl is a scaling expert regularly engaged by USAID on the topic. His facilitation work has focused on two projects: seed drying using bead technology and nets for reduced pesticide us in field vegetables. His work has involved two consultation trips to UC Davis and two scoping and evaluation trips – firstly to Bangladesh for assessment of the drying bead technology and then to Kenya for assessment of the net houses.

Objective/pillar 3 - Capacity building

In addition to student training, the Horticulture Innovation Lab 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 Innovation Lab 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 benefits 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.

One of the strengths of the Collaborative Research Innovation Labs is their role in building the capacity of students, faculty, institutions and participants in the horticultural value chain. Projects build capacity through training, information dissemination, and through the participation of students, local community members, and other value chain actors in project activities. For students, capacity building is embedded within the collaborative research program between U.S. universities and developing country institutions. The nature of these embedded programs ensures that the research students are engaged in is relevant to their home countries. In general, Horticulture Innovation Lab project research takes place in the focus country, which means that involved students are much more likely to find employment in their country and in their field of interest as a result their Horticulture Innovation Lab research experience.

Objective/pillar 4 - Nutrition

We support research that improves understanding of nutritious crops from production to consumption and enhances their availability.

Nutrition is uniquely important in poverty reduction. Improving on-farm crop diversity through horticulture increases the likelihood that a family will diversify their diet. Lack of diversity in the diet (low dietary diversity) is strongly associated with deficiencies of essential micronutrients such as vitamin A, folate (vitamin B9) iron, and zinc. Micronutrient deficiencies that start during childhood have long-term health and nutrition consequences that affect children's cognitive and physical development, and their overall well-being.

James Simon of Rutgers, The State University of New Jersey, leads a $2 million five-year project focused on improving dietary diversity through enhanced access to African indigenous vegetables in Kenya and Zambia. Once considered "famine foods," these indigenous vegetables such as amaranth, African nightshade and spider plant have increased in popularity — but meeting market demand still presents several production and marketing challenges. This project will work to improve the value chain for indigenous vegetables and will monitor how changes to vegetable production and marketing affect household consumption of these nutritious vegetables.

This project will track community's production, sales and consumption of AIVs in Kenya and Zambia. Selected communities will be trained in improved production practices, they will be supported and linked to markets where AIVs are a valued commodity, and they will be trained to prepare and consume these nutritious vegetables. Surveys will be completed throughout the life

of the project to determine household level changes in consumption and sales, as well as community level changes in market access and purchases of AIVs by non-intervention families.

All of our research projects use a nutrition sensitive approach, and seek to understand the roles of nutrition within their projects. Our major nutrition-focused project (five years, $2 million) has incorporated explicit nutrition objectives and indicators into its design. Beyond the major (five year) nutrition project, the Horticulture Innovation Lab will fund projects that have the potential to make positive impacts in nutrition. All of our projects will be reviewed to consider their nutrition-related impacts, both positive and negative.

Improvements in local and regional horticulture could help address two key components of food insecurity. Inadequate access to and availability of micronutrient-rich fruits and vegetables. High-value horticulture improves access through income generation all along the value chain and by making nutritious foods more available in the home and in local and regional markets.

The most successful horticulture interventions also address the third component of food insecurity; food use through behavior change communication, nutrition counseling, and other approaches.

The Horticulture Innovation Lab is committed to

- Furthering the understanding of these linkages
- Identifying best practices that can be used to improve nutrition through agricultural interventions
- Analyzing all of our projects with nutrition sensitive lens
- A nutrition sensitive research portfolio whereby all projects incorporate nutrition benchmarks and check-ins throughout the project lifecycle. Projects with an explicit nutrition objective, benefit or research focus will measure nutritional outcomes and results to show impact.

<u>Nutrition related activities (completed)</u>

- Conducted two seminars for the Program in International Community Nutrition at UC Davis.
- Solicited a 5 year nutrition and horticulture project and went through a through revision and program design process with the grantee.
- Participated in various webinars focused on the nexus of nutrition and agriculture.
- Worked with all project PIs to include nutrition sensitive practices into their projects.

<u>Nutrition related activities (ongoing)</u>

- Reviewing and summarizing horticulture specific lessons from the Nutrition Innovation Lab to disseminate best practices to project PIs and Regional Centers.
- Reviewing and promoting the Nutrition-Sensitive Agricultural Programing online course by USAID to project PIs and Centers. We hope to create a few materials that go along with the course to facilitate learning and stimulate discussion.

Objective/pillar 5 – Empowering women and the most vulnerable

In 2014-2015, the Horticulture Innovation Lab's research and interventions were aimed at empowering women and vulnerable people who often work in horticulture value chains. The

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

The Horticulture Innovation Lab aims to incorporate gender equity into all of our projects and in 2014-2015, we solicited and funded a proposal on gender equity.

Current projects aim to incorporate gender equity through the production of fruits and vegetables. Improving nutrition through indigenous vegetables in Kenya, Zambia, and Tanzania seeks to address gender inequality through the value chain. Developing small-scale irrigation solutions in Uganda works closely with smallholder women farmers who are often excluded from irrigation and marketing developments. Expanding tomato grafting for entrepreneurship in Honduras and Guatemala conducts field trials with women's group to validate the technology and identify the optimal rootstock-scions combinations. Promoting irrigation practices for smallholders in Cambodia and Nepal empowers women through labor saving technologies and increased horticulture production.

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

Objective/pillar 6 - Information sharing

The Horticulture Innovation Lab is committed to two elements related to information sharing, namely

1) Sharing of "Best practices" on information sharing, and
2) Sharing of specific information on technologies (both as Extension and Training)

<u>Best practices in information sharing.</u>

The first element of understanding "what are good practices in terms of how best to disseminate information?" involves members of the Horticulture Innovation lab who also work with and can develop synergies based on their work in other USAID projects like MEAS and INGENAES. Thus the benefits of lessons learned (best practices) from one project are shared in multiple directions across USAID projects to enhance the access farmers have to useful information under all the projects.

A major avenue for sharing best practices in extension is the Horticulture Innovation Lab's annual involvement in the World Vegetable Centers (AVRDC) International Vegetable Training Course (IVTC). This course which typically has participants from multiple countries provides the Horticulture Innovation lab the opportunity to reach a wide range of users, as annual workshops typically draw on participants from 10 or more countries.

An associated activity is the beginning to document the Extension systems within Southeast Asia countries. This work will be continued into the next period. An understanding of the key players and strengths of the different country systems will help better orient scaling activities. Part of the study is to also identify existing reports that provide useful context.

Increasing access to extension and training materials

The second aspect of information sharing is the development and sharing useable extension and training products. In this respect, there are three main activities

- Development and evaluation of materials
- Promotion through training and on-line
- Promotion through the Horticulture Innovation Lab Innovation Centers.

Technology documentation

Part of the technology documentation activity was to assess technologies in terms of their major characteristics (e.g., eased of implementation, breadth of potential spread, etc.). This analysis led to a prioritization of technologies for further development.

Other materials being developed include two manuals

- Solar irrigation
- Solar drying

Centers as focal points for technology dissemination

One of the key avenues for technology dissemination is the Innovation Centers (at Kasetsart University - Thailand, Zamorano University – Honduras, UC Davis – USA and the center being established in Zambia). The centers offer both physical access to various Horticulture Innovation Lab technologies and the expertise required to understand and teach about the technologies.

Other topics 4 - Media and communications

Articles about the Horticulture Innovation Lab and its work, Oct. 2014-Sept. 2015

- October 7, 2014: "Investing in Agriculture: It Makes Dollars and Sense" on Feed the Future Blog
- October 8, 2014: "Grow vegetables to make quick money" on Daily Monitor (Uganda newspaper)
- October 17, 2014: "New grant aims to build global food security through produce research" on UC Davis News
- October 17, 2014: "Building global food security through produce research" on UC Newsroom
- October 19, 2014: "$18.75M grant aims to build global food security" in Davis Enterprise newspaper
- October 19, 2014: "50 years of global ag success" in Davis Enterprise newspaper
- October 20, 2014: "New grant aims to build global food security through produce research" on Imperial Valley News newspaper
- October 21, 2014: "$18.75M To Boost International Efforts" on CA&ES blog
- October 22nd, 2014: "Horticulture Innovation Lab Student Wins BIFAD Award for Scientific Excellence in a Feed the Future Innovation Lab" on crsps.net
- October 28, 2014: "Horticulture student awarded" in UC Davis Plant Sciences Newsletter
- October 29, 2014: "Low cost device helps Kenyan farmers reduce waste" in The Standard (Kenya newspaper)
- November 7, 2014: "UC Davis student honored for horticulture excellence " in Davis Enterprise
- November 13, 2014: "Trellis Fund Opens Door To Developing World" in CA&ES Outlook magazine
- November 20, 2014: "Teaching the Skills for Innovation in Agriculture" in Feed the Future newsletter
- November 20, 2014: "U.S. Universities Step Up to Fight Hunger" in Feed the Future newsletter
- December 12, 2014: "Reflecting on Progress and What Matters Most" in Feed the Future newsletter
- January 12, 2015: "$18.75 million grant to boost international fruit and vegetable research" in College of Agricultural and Environmental Sciences E-News
- January 29, 2015: "Partnering with the Private Sector on Food Security" in Feed the Future newsletter
- January 29, 2015: "Beads and Seeds: How Feed the Future and a Company Called Rhino Research are Helping Vegetable Farmers" in Feed the Future newsletter
- February 2nd, 2015: "New Trellis Fund Projects Awarded" on UC Davis College of Agricultural and Environmental Sciences website
- February 23, 2015: "Project looks to horticulture value chain to improve outlook for Honduran women" from Penn State News
- March 18, 2015: "How seed-drying beads can empower farmers in the tropics" on SciDev.Net with video
- March 31, 2015: "Conservation Agriculture Reduces Time and Labor for Women in Cambodia" in Feed the Future newsletter

- April 8, 2015: “Project looks to horticulture value chain to improve outlook for Honduran women” on International Program News from Penn State email newsletter
- April 20, 2015: “How a Global Trip Inspired This Californian to Focus Locally” on Feed the Future website
- May 12, 2015: “‘Local’ farm inspiration from half a world away” on UC ANR Food Blog and UC ANR homepage
- June 11, 2015: “Amanda Crump honored by the Association for International Agriculture and Rural Development” on College of Agricultural and Environmental Sciences Currents
- June 6, 2015: “Simple agricultural innovation to empower farmers” on SciDev.Net with video
- June 23, 2015: “LAURELS” in UC Davis Dateline (Crump AIARD award)
- July 16, 2015: Global Horticulture Knowledge Bank featured in FSN Network newsletter
- July 21, 2015: “Healing Plants to Feed a Nation” on Feed the Future website (mentions nets)
- July 30, 2015: “(Project management of value chain for harvest collection at the agricultural training)” on Agrilife and on bdkrishinews, news websites in Bangladesh
- August 3, 2015: “Reunion Annual del Horticulture Innovation Lab UC Davis Zambia-Africa” in Zamorano news
- August 4, 2015: “(Closing session of Agricultural Value Chain project’s post-harvest training and workshop)” on Agrilife website (Bangladesh)
- August 12, 2015: “Name droppers: Beachy, Ronald earn biotech accolades” in Davis Enterprise newspaper
- August 12, 2015: “Beth Mitcham receives ASHS Outstand International Horticulturist aware and Amanda Crump Honored by the Association for International Agriculture and Rural Development” in UC Davis Plant Sciences newsletter
- August 18, 2015: “Elizabeth Mitcham Honored As Outstanding Horticulturist” on Growing Produce website
- August 19, 2015: “Elizabeth Mitcham Honored As Outstanding Horticulturist” in American Fruit Grower email marketing
- August 19, 2015: “Researchers honored at Hort Science conference” on Good Fruit Grower
- August 21, 2015: “Global Insights: Trellis students work abroad” in Davis Enterprise newspaper
- August 24, 2015: “Hablas plantas? CALS hosts vegetable grafting workshop in Spanish” on University of Wisconsin-Madison eCALS newsletter
- September 3, 2015: “Names in the news” in UC ANR Report
- September 29, 2015: “Farm to Table Academy leads off ‘food month’” in UC Davis Dateline
- September 30, 2015: “ Grand opening: Horticulture Innovation Lab Demonstration Center, October 16” in UC Davis Plant Sciences newsletter

Issues

Over the course of the year, our biggest issues were delays in contracting. We were working with a new staff member in our granting and contracts office and that person was unresponsive. After raising this issue to the level of the vice provost, we were able to resolve the problem and our contracts have been moving along quickly. Other issues that we encountered this year were outlined in the Trellis report related to security and safety of students.

Future directions

In the next year, the Horticulture Innovation Lab will fund a major research project in postharvest, support research to scale the pest exclusion nets in Kenya, solicit and fund research projects that support Mission work, solicit and fund value chain research, and solicit and fund an integrated pest management project in Central America. We will work to continue to learn from projects and disseminate information learned over the past six years.

List of appendices

1. List of awards given to U.S. universities to include project name, dates and funding (current year and total)
2. Three distinct success stories
3. Rapid assessment of the horticulture sector in Guinea
4. Open data management plan
5. Monitoring and evaluation plan

Appendix 1 - List of awards given to U.S. universities to include project name, dates and funding (current year and total).

1) University of California, Davis
   a) Horticulture Irrigation Project (HIP): Innovations in Dry Season Horticulture for Women and Smallholders in East Africa for income, nutrition, and climate resilience
   b) January 2015 to January 2017
   c) Total funding: $299,616 ($158,439 in FY15)

2) The Pennsylvania State University
   a) Women in Ag Network (WAgN): Honduras
   b) January 2015 to July 2019
   c) Total funding: $1,220,455 ($272,063 in FY15)

3) University of Wisconsin-Madison
   a) *Plántulas de Esperanza* (Seedlings of Hope)
   b) May 2015 to May 2017
   c) Total funding: $299,729 ($149,869 in FY15)

4) North Carolina Agricultural and Technical State University (HBCU)
   a) Incentives and Markets for Vegetable Smallholders to Practice Water and Labor Saving Technologies
   b) January 2015 to January 2017
   c) Total funding: $299,495 ($155,093 in FY15)

5) Rutgers, the State University of New Jersey
   a) Improving Income and Nutrition of Smallholder Farmers in Eastern Africa using a Market Driven Approach to Enhance Value Chain Production of African Indigenous Vegetables
   b) January 2015 to July 2019
   c) Total funding: $2,000,000 ($400,000 in FY15)

Appendix 2 - Three distinct success stories.

‘DRY CHAIN’ PARTNERSHIP HELPS FARMERS STORE SEED BETTER

A partnership between university scientists and a private technology company has sprouted both new concepts and new tools that can help vegetable farmers in developing countries access better seeds.

For many smallholder farmers, buying and trading vegetable seeds can be risky. The benefits of purchasing seed can be high, with improved crop varieties offering disease resistance, increased vigor and improved taste. But the risks of receiving poor-quality seed are also significant, particularly in tropical climates. Seed will deteriorate rapidly if it is not properly dried and stored. The resulting poor germination reduces yields, which for vegetable farmers can mean staggered harvests and inconsistent crop quality.

“If you buy seed and it’s all dead, you aren’t going to buy very much more seed,” says Kent Bradford, seed biologist at the University of California, Davis. “To get improved varieties into farmers’ hands, you must have a system where people can buy and trade seed successfully.”

Under the Horticulture Innovation Lab, Bradford and an international team have partnered with Rhino Research, a seed technology company in Thailand, to improve the science and tools available for drying and storing vegetable seed. The team initially sought to better maintain seed quality by exploring zeolite-based “drying beads.”

Produced by Rhino Research, the drying beads absorb moisture from the air. When sealed with seeds in an airtight container, the beads reduce the seeds’ moisture content to very low levels. They can be re-used repeatedly, after being reactivated in an oven.

In Thailand, India, Nepal and Bangladesh, the team developed protocols for how to best use drying beads with vegetable seed and trained more than 3,600 people in their use. The team’s preliminary economic analyses showed that using drying beads could increase earnings within the onion seed industry in Nepal by an additional $5.85 million per year.

HORTICULTURE INNOVATION LAB PHOTO

Kent Bradford, right, discusses how to use drying beads to save horticultural seed with scientists and entrepreneurs at a meeting in Kenya held by the Horticulture Innovation Lab.

But working with smallholders in developing countries presented additional challenges. While the cost of drying beads can be recovered through repeated use, the up-front costs were not reasonable for many small-scale farmers. Accustomed to working with seed companies, the team also assumed the importance of drying seeds was “fairly common knowledge,” but quickly learned that was not the case.

“But when we started talking in terms of the ‘dry chain’ for seeds, then the idea clicked,” Bradford says. “When we compare the importance of drying seeds and keeping them dry throughout storage to the ‘cold chain’ [i.e. keeping perishable goods cold during storage and transport], then our ability to communicate with people goes up.”

A “dry chain” requires that seed be dried, and the dryness monitored and maintained throughout all stages of storage. Many actors along the seed dry chain—from seed production to storage, transportation, sales and on-farm use—need to maintain that dryness to ensure seed quality.

Following the new dry chain concept, the Horticulture Innovation Lab team also developed a suite of tools appropriate for the different participants along the chain, using what they learned from working with the drying beads. The team’s next steps will begin with a commercial-scale drying system—the FlexiDry, which also uses drying beads—and continue down the dry chain to small containers with inexpensive sensors that enable farmers to maintain and monitor dryness during seed storage.

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D-LAB TEACHES INNOVATION SKILLS TO AGRICULTURAL STUDENTS

How do you teach innovation? A partnership under Feed the Future is empowering university students to solve real-world agricultural problems while learning the nuts and bolts of how to innovate.

"We set out to teach the students some skills in metal work, the design process and appropriate technology—and they end up learning empowerment and teamwork," explained Jorge Espinosa, with the Panamerican Agricultural School, Zamorano, in Honduras.

Espinosa is an instructor for Zamorano's version of D-Lab, a concept course originally started at the Massachusetts Institute of Technology. Now replicated and adapted for students at multiple universities, the D-Lab model focuses on "Development through Dialogue, Design and Dissemination."

Espinosa's work with D-Lab started at the University of California, Davis, where Kurt Kornbluth leads students through two D-Lab classes each year that result in feasibility studies and prototypes, with a focus on external clients' needs. One of Kornbluth's clients was the Horticulture Innovation Lab, which was seeking solutions for smallholder farmers, such as ways to keep fruits and vegetables cool during transport to market.

"After serving as a D-Lab client, we saw potential value in offering D-Lab courses to students at universities in Honduras and Thailand where we have Regional Centers that act as hubs for our work," said Britta Hansen, of the Horticulture Innovation Lab. "Not only could D-Lab provide skills to students—tomorrow's agricultural leaders—but it could also support our partners in adapting new solutions to local farming challenges."

Each university that offers D-Lab must adapt the course to meet its needs and standards. With its learn-by-doing ethos, Zamorano seemed like a good match for D-Lab.

HORTICULTURE INNOVATION LAB PHOTO / ERIN MCGUIRE, UC DAVIS

Instructor Jorge Espinosa discusses how to recycle an old saw blade with college students studying agriculture at the Panamerican Agricultural School, Zamorano, for a project during a D-Lab course in Honduras.

"[Zamorano] is very hands-on, but it can be mechanical, like a recipe. I think that is the magic of D-Lab, that the students are not given recipes," Espinosa said. "We have adapted it to not be a class, but a work experience—a learn-by-doing module, Zamorano style."

So far 70 Zamorano students have participated in six D-Lab modules, intended to foster student creativity and provide a space to make mistakes and learn from them.

In a curriculum review, 71 percent of Zamorano's D-Lab students reported they would "definitely respond more creatively" when approaching future problems, and 87 percent reported being very comfortable with presenting new ideas in D-Lab. Overcoming an aversion to failure proved to be an essential component of the course. On average, students built more than three prototypes for every one prototype that worked as expected, with 80 percent learning "very much" from failed prototypes.

"What I am taking [from D-Lab] is the magnificent experience of practically inventing something," reported one student. "Like [Espinosa] said to us once: There are no mistakes, there are only opportunities to develop… You always learn in the end."

In addition to the D-Lab course at Zamorano, the Horticulture Innovation Lab team has started a D-Lab at Kasetsart University in Thailand, with 29 students in its first class. The Horticulture Innovation Lab Regional Centers continue to support and improve D-Lab courses at these universities.

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REDUCING DRUDGERY, IMPROVING SOIL FOR VEGETABLE FARMERS

Most commonly used with field crops, conservation agriculture combines three practices that help farmers invest in soil health, specifically:

- minimal soil disturbance ("no till"),
- continuous mulch cover, and
- rotating diverse crops.

These practices can also reduce labor and reduce water evaporation from the soil.

Manuel Reyes, professor at North Carolina Agricultural and Technical State University, has helped farmers in many countries improve their soil and use water efficiently. In doing so, he has also partnered with three Feed the Future Innovation Labs, funded by the U.S. Agency for International Development.

Beginning in 2010, Reyes started working with farmers in Cambodia on conservation agriculture for field crops, with an international team supported by the SANREM Innovation Lab. Two year later, the team worked with 56 households over 149 hectares to use conservation agriculture principles.

After testing conservation agriculture practices with vegetable crops in the United States, Reyes expanded his conservation agriculture work in Cambodia to focus on vegetable farmers. Now with additional funding from the Horticulture Innovation Lab, he added drip irrigation to conservation agriculture practices for vegetable the farmers. This research sought to find whether combining these practices could reduce labor needs, increase yield, increase income and ultimately receive support from vegetable farmers.

For field trials in Cambodia, women farmers grew a variety of vegetables, including string beans, cucumber, Chinese cabbage, kale, tomatoes and eggplant. Unlike the first few years of using conservation agriculture with field crops, this trial with vegetables found no significant differences in yields or income between the various treatments.

HORTICULTURE INNOVATION LAB PHOTO / MANUEL REYES, NC A&T

Women farmers in Cambodia are combining drip irrigation with conservation agriculture to grow vegetables with less drudgery, while improving soil health.

But what did change with the new practices was the farmers' labor. The researchers estimate that growing vegetables on 100 square meters with traditional methods and hand watering requires hauling about 1,300 pounds of water per day during the dry season — and even twice as much during very dry seasons. Drip irrigation and conservation agriculture freed the women farmers from carrying water, tilling and weeding.

Many of the women farmers were so pleased with the new practices that they asked to end the experiment early, to avoid the extra labor of tilling, hand-watering and weeding required to maintain the field tests.

The next step? Reyes is working with these Cambodian women farmers on a new Horticulture Innovation Lab project, this time on marketing their vegetables and building a local brand that promotes their conservation practices.

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Appendix 3 - Rapid assessment of the horticulture sector in Guinea

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RAPID ASSESSMENT OF THE HORTICULTURE SECTOR IN GUINEA

OCTOBER 29, 2015
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 (Horticulture Innovation Lab) at the University of California, Davis.

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All photos by Peter C. Shapland.

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CONTENTS

ACRONYMS

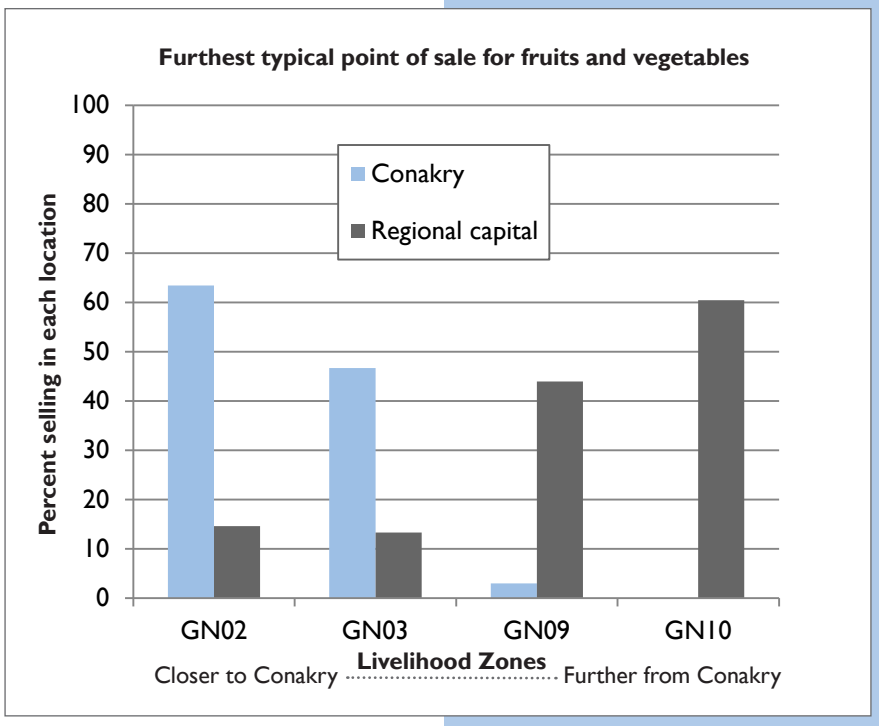
AFTT	*Association des Femmes Techniciennes et Technologues*
ANPROCA	*Agence Nationale de la Promotion Rurale et du Conseil Agricole*
AVRDC	The World Vegetable Center
BMI	body mass index
COPEFL	*Coopérative des Producteurs et Exportateurs des Fruits et Légumes de Friguiagbé*
COPRAKAM	*Coopérative des Producteurs d'Arachide de Karité et de Miel*
DHS	Demographic Health Survey
ECOWAS	Economic Community of West African States
ENAE	*École Nationales d'Agriculture et d'Élevage*
FAO	Food and Agriculture Organization of the United Nations
FEWS NET	Famine Early Warning Systems Network
FUMA	*Federazione delle Unioni di orticoltori della Haute Guinée*
GAPs	good agricultural practices
GDP	gross domestic product
GIS	geographic information system
GN	Guinea country code, used for FEWS NET Livelihood Zones
IFPRI	International Food Policy Research Institute
IFDC	International Fertilizer Development Center
IRAG	*Institut de Recherche Agronomique de Guinée*
ISAV	*Institut supérieur agronomique et vétérinaire*
NADP	National Agricultural Development Policy - Vision 2015
NEPAD	New Partnership for Africa's Development
NGO	non-governmental organization
PNAAFA	National Programme to Support Agricultural Value Chain Actors
PNIASA	Plan of National Agricultural Investment and Food Security
PPP	purchasing power parity
SUN	Scaling Up Nutrition
U.S.	United States
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WFP	United Nations World Food Programme
WHO	World Health Organization

EXECUTIVE SUMMARY

Developing the horticulture sector in Guinea is an important part of improving the capacity of smallholders to grow, eat, and market fruits and vegetables. Increasing both household and commercial production, marketing, and storage of fruits and vegetables leads to diversified cropping systems, diversified diets, and greater resiliency. With funding from the U.S. Agency for International Development, the Feed the Future Innovation Lab for Collaborative Research on Horticulture (Horticulture Innovation Lab) conducted an assessment of horticulture in Southern Guinea to identify the major constraints to improving household and commercial production of fruits and vegetables. This report outlines the assessment and recommendations of activities that donors can support to address these constraints and improve the horticulture sector in Guinea.

The Horticulture Innovation Lab's rapid assessment team surveyed farmers and village leaders, interviewed stakeholders and surveyed market traders in four zones of Guinea.

This rapid assessment presents a snapshot of horticulture in Guinea through three on-the-ground assessments and a desk study conducted from May to September in 2015. This assessment was designed to serve as guidance for new initiatives to address constraints in the horticulture sector. The assessment detailed in this report includes considerations of farmers, institutions and markets while looking at the entire horticultural sector from seed systems to markets, with special consideration to gender and nutrition.

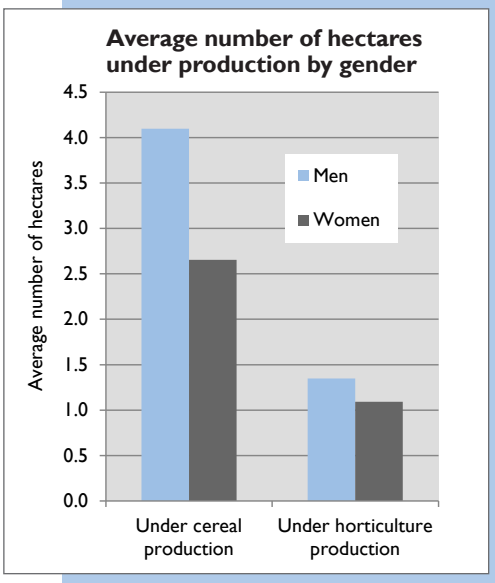


Our rapid assessment uncovered several interesting things about the horticulture sector in Guinea. By looking at four different Livelihood Zones and levels of wealth, we discovered that horticultural production decreased as we moved away from Conakry. We assumed that this was because of the distance away from the major metropolitan area where there is higher demand for goods, but this was just part of the story. Farmers did sell in Conakry if they could, but they also accessed well-established weekly regional markets, even if that meant traveling to a neighboring country. Farmers were motivated to sell whenever they had extra produce. Even the poorest of farmers would rent a car or ride a long distance on a bus if they thought they could access the market. This shows the resiliency and determination of the Guinean farmer. But we also know that the poorest

Though road conditions are often poor, farmers growing horticultural crops ride long distances on a bus or rent a car to take their produce to established regional markets.

farmers make difficult choices, often selling their staple crops to pay for expenses now only to later purchase the staple food at higher prices. So while Guinean farmers are resilient, they are also living on the margin. Our recommendations outline steps to improve the resiliency of the Guinean farmer.

When our team looked at gender divisions in horticulture production, many things surprised us. Like women all over the world, the women in Guinea grow a lot of vegetables. And like other women, they are constrained by their ability to purchase inputs and they use their profits from horticulture to pay for food and other living expenses. However, we learned that a woman's horticultural production often becomes more sophisticated when her husband's own horticultural production improves. Men also told us that they value what the women know, including what the women learn from their time in markets. Men widely reported that they adopted varieties from the women because women learn about the new varieties first.



We also learned that Guineans measure wealth based on labor and access to equipment. This coincides with their willingness to belong to groups. Whether talking to a farmer or a marketer, our surveyors found strong participation in *groupements*. These groups offer a great opportunity for horticultural sector development through the implementation of savings groups or the creation of specialized processing and postharvest groups like the Kanya Nema.

Women growing horticultural crops generally adopt more sophisticated field practices when their husbands also grow fruits and vegetables.

Finally, when we looked across the horticulture sector, we discovered that great gains could be made by investing in nutrition training, postharvest processing and food preservation. Farmers who succeed at horticultural production would benefit from training in postharvest handling, packaging and storage. Consumers would benefit from having access to better stored and better processed foods. Supporting crop diversification, investing in the seed system, and scaling-up labor-saving technologies would strengthen the horticulture sector across all wealth classes, genders, and Livelihood Zones.

SUMMARY OF RECOMMENDATIONS

A horticulture sector strategy that intentionally prioritizes rural revitalization—one that empowers individual communities to take control over their livelihoods and create their own opportunities for agricultural investment and growth—is a strategy that would find support and success in rural Guinea. In particular, we provide the following recommendations:

HORTICULTURE SECTOR RECOMMENDATIONS

- **Inputs:** Facilitate access to loans or small grants and support seed production (research- or field-level) and seed banking techniques.
- **Production:** Promote simplified and sustainable farming techniques, conservation agriculture practices in horticulture, and basic fencing and animal husbandry practices to protect gardens.
- **Pest management:** Train agricultural extensionists in pest identification and provide training to farmers in the five components of integrated pest management.

- **Credit:** Create partnerships with local banks and with bankers who understand horticulture and support savings groups.
- **Entrepreneurship and marketing:** Promote the standardization and marketing of horticultural products, develop and reinforce technical exchange and support among horticulture actors, support training in basic agro-entrepreneurship skills and postharvest techniques, invest in simplified postharvest technologies, develop farmers' skills in record keeping, and conduct market research to support local agribusinesses.
- **Postharvest:** Provide training in basic postharvest practices; set up collection centers; and support smallholder processing of mango, avocado, banana, tomato and eggplant.
- **Policy:** Support the development of government policies in horticulture that create market opportunities for smallholders; support governments in setting minimum standards for the importation and sale of fertilizers, pesticides, seeds and other inputs; and provide opportunities for policy makers to attend regional workshops and conferences on creating a competitive, private sector-led fertilizer and input industry.
- **Nutrition:** Support interventions in household gardening along with nutrition counseling, education and behavior change communication; and take a broad, community-level approach to nutrition

SUPPORT FOR PARTICULAR CROPS

- **Chili pepper:** Develop a seed marketing initiative, provide training in good agricultural practices (GAPs), build linkages between growers and international markets, and improve the processing.
- **Okra:** Increase support of production and drying.
- **Eggplant:** Improve irrigation for dry-season production, improve the quality and availability of fertilizers in local markets, and support research on better production and postharvest practices.
- **Tomato:** Support research and testing of new varieties and pest management strategies; develop Guinean institutional capacity to design and implement GAPs for tomato; and invest in postharvest interventions of shade, packaging, and processing.
- **Mango:** Support integrated pest management strategies for fruit flies, facilitate the dissemination of improved varieties, and invest in postharvest handling and storage and processing.
- **Oranges:** Support research in pests of oranges and orange trees.

RECOMMENDATIONS FOR WOMEN FARMERS

- Improve upon traditional drying methods
- Encourage the production of fruits and vegetables by men and women alike to capitalize on the advantages that each provide to the other.

RECOMMENDATIONS BY WEALTH QUARTILE

- **For wealthier growers:** Invest in postharvest education and production technologies; and introduce conservation of products through juicing, canning, pulping and freezing.
- **For middle-income growers:** Provide training in postharvest skills and postharvest technologies.
- **For poor growers:** Support training and research in production; assess time and labor allocations for these farmers and design approaches based on those; and provide basic training on home gardens and nutrition.
- **For poorest growers:** Conduct training programs with a goal of improving basic production, improve access to inputs, introduce home gardening where it doesn't exist, and create improved access to social safety nets.

RECOMMENDATIONS FOR HUMAN AND INSTITUTIONAL CAPACITY DEVELOPMENT

- Develop the extension system in Guinea through strengthening the national extension system, *Direction Nationale d'Agriculture,* and investing in extensionists.

RECOMMENDATIONS BY LIVELIHOOD ZONE

- **Zone GN02 (Piedmont Zone):** Take a value chain development approach that focuses on postharvest management, improved postharvest technologies, building market linkages and organizational development.
- **Zone GN 03 (Central Plateau zone):** Improve postharvest handling and packaging.
- **Zone GN 09 (Wooded Savannah Zone):** Focus on diversification and introduction of improved varieties and cropping diversity; support this zone in becoming a hub of seed production; and support crop diversification, technical training, organizational development, introduction of new and/or adapted crop varieties and facilitating commercialization.
- **Zone GN 10 (Pre-Forest Zone):** Initiate and support crop diversification opportunities and small scale irrigation, provide training on seed production and conservation, promote appropriate postharvest technologies and management, improve upon traditional drying methods, and scale-up labor-saving production methods.

INTRODUCTION

Developing a horticulture sector offers the opportunity to meet food needs and improve nutrition and health, while also providing prospects for income diversification and economic advancement of the rural poor. In addition, since women are the main producers and marketers of horticultural crops in many regions, increased horticultural production often leads to an improved income stream for women and their children. Horticultural crops are both highly nutritious and economically valuable. Horticulture sector development is crucial to enabling small-scale producers to overcome agricultural market barriers and realize the benefits offered by horticultural development.

Horticultural production in the Republic of Guinea, particularly the southern region, faces the typical production and marketing constraints of other regions in West Africa. The Feed the Future Innovation Lab for Collaborative Research on Horticulture (Horticulture Innovation Lab) conducted a rapid assessment of horticulture from May to September 2015. This assessment of horticulture in Southern Guinea focuses on identifying the pivotal investments that donors can make to:

1. Improve household capacity of smallholders to efficiently grow vegetables and fruits (eaten by families) for the longest season possible, accompanied with associated understanding of the importance to properly prepare, store, and consume nutrient-rich foods; and

2. Improve commercial capacity to produce, harvest, add value to, and market high-demand horticultural (fruit and vegetable) crops.

This report is a summation of the desk study and three on-the-ground assessments. It takes into account the entire horticulture sector of Guinea, ranging from farmers to markets and individual to institutional capacity. The analysis considers all of the data compiled and identifies common needs across the horticulture sector. The conclusions presented are intended to provide donors with strategies to address these needs.

ABOUT GUINEA

Located in West Africa, the Republic of Guinea has a young population of around 11 million people. Despite the abundance of natural resources, including mining, fertile areas with low population density and coastal access, Guinea faces major social, economic, and health related challenges. In 2013, Guinea was ranked 178th out of 187 countries in the United Nations Development Program's Human Development Index (UNDP, 2013). Democracy is relatively new to Guinea, elections were held in 2010, the first since independence. Guinea's location in West Africa has had a great influence on its economic and social mobility; conflicts in neighboring Sierra Leone and Liberia have often spilled over its boarders along with hundreds of thousands of refugees throughout the 1990s. The country is also vulnerable to natural disasters such as flooding.

Guinea is a young country. In 2012, more than 16 percent of the population were under 5 years old and two-thirds were under 15, while just 3 percent were over 65 years old. The country is experiencing a drive to cities and towns with 36 percent of the population living in urban centers in 2010 (UNDP, 2013). Over the past 20 years, per capita gross domestic product (GDP) has risen modestly from $1,128 purchasing power parity (PPP) to $1,215 PPP (World Bank, 2014) while the under-5 mortality rate has fallen promisingly from 241 deaths per 1,000 live births to 101 deaths per 1,000 live births (UNICEF, 2012). However, these trends are modest in comparison to other countries in sub-Saharan Africa, indicating

that Guinea still struggles with serious challenges to the health and wellbeing of both their rural and urban populace.

Rapid population growth in both urban and rural areas will compound current food security issues as well as magnify changes in urban and rural population changes. Average annual urban population growth rate is currently 3.9 percent while rural is lower at 1.8 percent (UNDP, 2013). Within West Africa, Guinea has the lowest urbanization rate; however urbanization will continue at a steady pace and will lead to increasingly complex problems to be solved. By 2020 the urban population will have doubled, which will pose problems related to spatial planning, equipment and infrastructure management, environmental preservation and protection, and of course food security for urban dwellers with growing purchase power (Hatcheu, 2008). In summary, demographic trends in the medium- and long-term advocate a proactive policy both in urban and in rural areas.

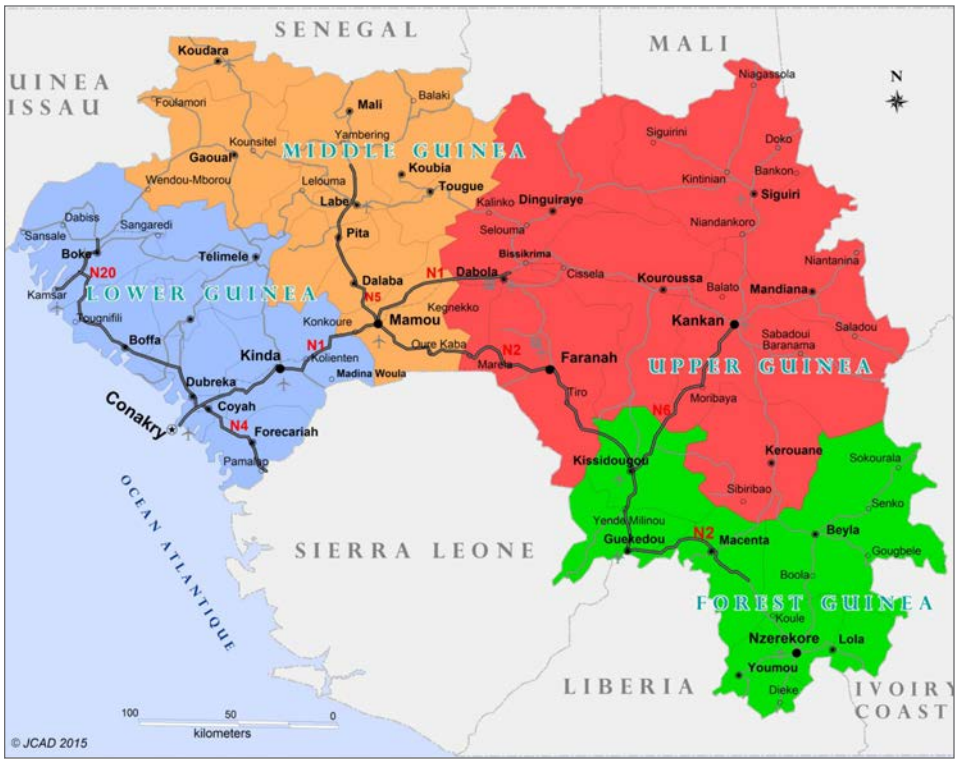


Figure 1. Map of Guinea's four natural regions, Hatcheu Emil Tchawe, JCAD International, 2015.

The average population density in Guinea (29 inhabitants per km^2) hides significant disparities. While the population density in some rural sub-prefectures such as in Middle Guinea and the Forest region exceeds 100 inhabitants per square kilometer, it drops to less than 5 inhabitants per square kilometer in large areas of Upper Guinea. The least populated sub-prefecture, Sangardo near Kissidougou has less than 1 inhabitant per square kilometer.

In terms of administrative organization, Guinea is divided into eight regions (Conakry, Kindia, Boke, Mamou, Faranah, N'Zérékoré, Kankan and Labé). In total 33 prefectures and 305 sub-prefectures are spread throughout the country. The country is geographically divided into four natural regions (figure 1):

- The Maritime Guinea (Lower Guinea) on the edge of the Atlantic.
- The Fouta (or Middle Guinea) south of Senegal, to the highlands with many rivers designated as the "water tower" of West Africa.
- The upper Niger basin (or Upper Guinea): forming a vast savannah transition zone with Mali.
- Forest Guinea is an area of forested mountains in southeast Guinea, near Liberia.

The Southern Guinean region from Beyla to Forecariah prefectures used to be a "food reserve" for the country but has been exposed to massive displacement of people recently because of mining and railroad construction. Most people living in this area rely on small-scale family farming through field crops, gardening and plantations for their living. The varied landscape contains mountains, forests, savannah and lowlands where farming is mostly practiced during rainy season (May-October). Most gardening activities practiced in this season are done around homes as people focus more in staple crops. Few people farm vegetables and are oftentimes organized in cooperatives with support from non-governmental organizations (NGOs), research or government entities.

Table 1. Famine Early Warning Systems Network (FEWS NET) Livelihood Zones, used for assessment by the Horticulture Innovation Lab from May to September 2015.

Zone	Characteristic Livelihoods	Prefectures
GN02	Piedmont: Rice, Groundnut, Horticulture	Forécariah
		Kindia
GN03	Central plateau: Horticulture, Fonio, Livestock	Mamou
GN09	Wooded savannah: Rice, Cassava, Groundnut	Dabola
		Faranah
		Kissidougou
		Kérouané
GN10	Pre-forest zone: Rice, Cassava, Livestock	Beyla

According to the Food and Agriculture Organization of the United Nations (FAO, 2014), over the last 5 years the share that agriculture contributes to GDP in Guinea has steadily decreased, from 26 percent to 20 percent. For most Guineans, agriculture is both the main source of sustenance and income, even if agricultural productivity is low. The poor state of roads, water supply and electrical infrastructure hinders both the storage and transport of food to market; therefore, most of Guinea's agricultural production is intended for direct consumption or local markets.

Rice is by far the most important crop, accounting for about 80 percent of the area under cereals and about 50 percent of irrigated land. Other food crops include cassava and corn. In addition, Guineans grows cash crops, including cashew nuts, cocoa beans, coffee and rubber, which constitute the bulk of agricultural exports. However these only contribute to 10 percent of national GDP. Rubber exports constitute about 30 percent of total exports of cash crops, followed by cocoa beans, which represents 27 percent of exports.

Guinea's agriculture is dominated by family farms. These farms cover approximately 60 percent of agricultural land and provide some level of employment to about 95 percent of the population. This type of operation, usually small (0.30 to 0.50 hectares) contains both production for consumption as well as sales or trade. The end consumer of produce grown on these small landholdings often depends on a grower's access to water, transportation, and market linkages. Rain-fed crops are predominant and represent 95 percent of the total area. Among rain-fed crops, over 40 percent are located on hills or mountains of Middle and Upper Guinea and 30 percent on Lower Guinea trays. The lowlands and mangrove of Forest Guinea (Livelihood Zones GN10 and GN11) represent a largely untapped potential.

In 2012 the United Nations World Food Programme (WFP) and partner organizations reported that throughout Guinea 27 percent of households are food insecure, while 3 percent are severely food insecure. According to another 2014 survey, the nationwide chronic malnutrition rate among children is 34.5 percent; it exceeds 40 percent in Labé, Boké and N'Zérékoré (World Bank, 2014). The Ebola outbreak, which started in December 2013, has taken more than 3,000 victims in the country, most of whom are farmers in rural communities (CDC, 2015). This southern region has had the highest number of victims and rehabilitation is yet to be started for survivors and their families. The Ebola outbreak has impacted both production and commercialization, both exports and prices (FEWS NET, 2015).

This rapid assessment focused on the four Famine Early Warning Systems Network (FEWS NET) Livelihood Zones in Southern Guinea (table 1).

In FEWS NET Livelihood Zone GN02, the Piedmont Zone, the main economic activity for rural populations is the production of rice, groundnut and horticultural crops. Bananas, citrus, papaya and pineapple are important crops in the southern portion of the zone and mangoes, palm oil, okra, chili pepper, eggplant, cucumber and watermelon are grown throughout the zone. An abundant rainy season from May to October provides 2,000–2,500 mm of rainfall per year. While wealthier households are able to grow most of the grain they consume, poor households produce roughly five months' worth of their grain consumption, and purchase imported rice for the other seven months. This is the biggest horticultural

producing area in the country with fertile low lands, good rainfall and opportunities to export to the capital and to neighboring Sierra Leone. Kindia has the largest market of imported seeds, the seed producing research center (Kilissi) and the largest fruit tree plantations.

The Central Plateau Livelihood Zone, GN03, has relatively fertile soils and 1,500 to 2,000 mm of rainfall per year. The main economic activities in the Central Plateau Zone are horticulture, fonio and livestock. The Peuhl (an ethnic group of herders) are a dominant ethnic group in the zone and the most common animals found among smallholders are small ruminants. High topographical relief often inhibits the use of draft animal power in this relatively mountainous zone with high plains and temperate prairies. The main fruits in GN03 are mangoes, palm oil, avocados, bananas and oranges. Market gardening is also very important in the zone with potatoes, sweet potatoes, okra, chili pepper, eggplant and tomatoes taking the lead roles. This zone consists of hilly areas and gravelly fertile soils. Producers have the opportunity to export to Sierra Leone, most regional capitals across the country and to Conakry. Well-developed farming cooperatives exist in this area composed of women, youth and men.

Livelihood Zone GN09 is aptly named the Wooded Savannah Zone and is a transitional zone between the forested region in Southern Guinea and the savannah plains. The main economic activity in the Wooded Savannah Zone is the production of rice, cassava, and groundnut. This zone receives 1,500 to 2,500 mm of rain per year. Young men often immigrate to mining towns to find work during the dry season. The major horticultural crops in GN09 are mangoes, oranges, avocados, okra, chili pepper, and eggplant. Vegetable farming is mainly developed in suburban areas in Kankan (Bordo), Dabola and Faranah (Tindo). This zone has some of the most fertile soils in Guinea, but horticulture is less developed in the area. Dabola contributes highly to overall national peanut production. Kerouane is a diamond mining area which attracts all social categories leaving few people involved in horticulture. Most plantains sold in Kissidougou come from the forest region (mainly Macenta and N'Zérékoré). Fruit tree planting is also less developed in this zone, mostly limited to family compounds and home gardens.

Finally, Livelihood Zone GN10, the Pre-Forest Zone, has sandy, clay soils and 1,500 to 2,000 mm of rainfall per year. The main economic activities in this zone are rice, cassava, and livestock. The major tree crops in the zone are mangoes, palm oil, oranges, bananas and avocado, with some coffee, while the major vegetable crops are okra, chili pepper, and eggplant. GN10 is rich in minerals, including diamonds, which reduces the amount of labor available for agricultural production. Poor households are unable to produce enough grain and resort to buying grains for 5 months out of the year. Beyla is the zone with the most fertile soils, but with the poorest horticultural production. Vegetables, when grown, are usually not rotated with other crops. Crops grown the most locally are: eggplants, beans, bananas, maize, mangoes and pepper. Beyla has the potential to export to Cote d'Ivoire and to the regional capitals N'Zérékoré and Kankan.

RAPID ASSESSMENT METHODOLOGY

The Horticulture Innovation Lab conducted a desk study and three on-the-ground assessments in this rapid assessment. The desk study explored previous horticulture assessments, nutritional status and needs, and postharvest strategies in Guinea and the surrounding region. A three-week, on-the-ground survey in June focused on farmer characteristics and needs, this is described as the "farmer assessment." An 11-day, on-the-ground survey in August focused on institutional and human capacity this is the "stakeholder assessment." A two-week, on-the-ground "market assessment" was completed in August. The on-the-ground assessments took place in June and August 2015 and were conducted along the proposed Rio Tinto funded railway that will eventually be built between Conakry and Beyla. This region runs along the southern part of Guinea that borders Sierra Leone and Liberia (figure 2).

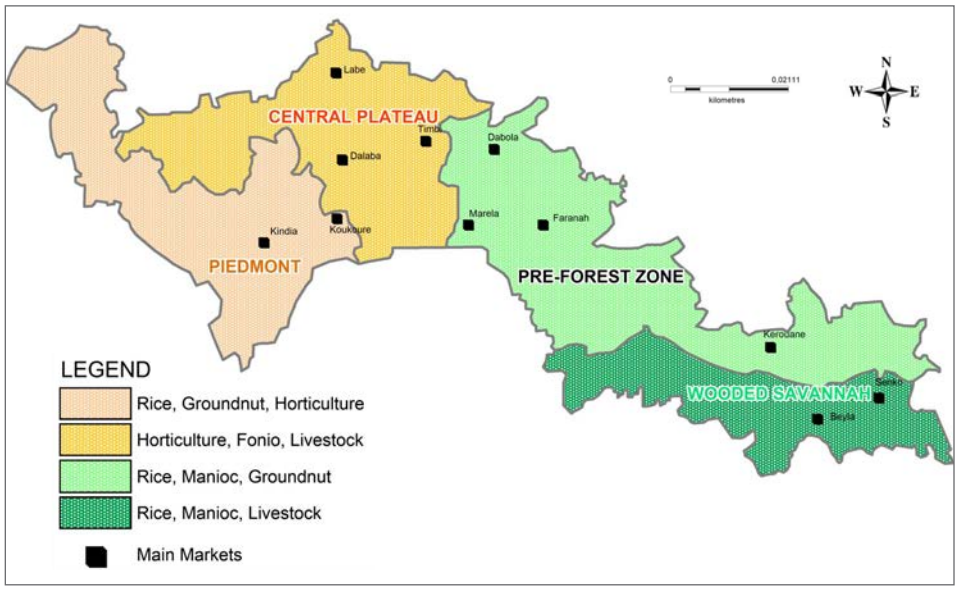


Figure 2. Livelihood Zones focused on in this assessment by the Horticulture Innovation Lab from June to September 2015, Hatcheu Emil Tchawe, JCAD International, 2015.

FARMER ASSESSMENT METHODS

A survey of households and focus groups was conducted in June 2015. This survey took place in villages in each targeted Livelihood Zone. In total, 15 villages were surveyed through 14 focus groups and 190 household surveys (table 2). The research team consisted of four multi-lingual surveyors and a lead researcher who was a Horticulture Innovation Lab-trained American development professional living in West Africa.

Table 2. Survey zone for farmer assessment conducted by the Horticulture Innovation Lab in June 2015.

Livelihood Zone	Prefecture	Sub-Prefecture	Village	Focus Groups	Individual Surveys
GN 02 Piedmont Zone	Forécariah	Mafieringé	Madinagbé	3	43
	Kindia	Diamakhaniy	Meyiwa		
		Friguiagbe	Massaya		
GN 03 Central Plateau Zone	Mamou	N'donnel	Sanama	3	32
		Timbo	Lingueya		
		Oure Kaba	Bantamaga		
GN 09 Wooded Savannah Zone	Faranah	Nialiaya	Layadoula	5	70
		Bendon	Dalafilany		
	Kissidougou	Massakoundo	Fermessadou		
		Aldardariya	Telikoro		
	Kerouané	Kerouané	Bafouron		
		Kosankora	Boulagnosol		
GN 10 Pre-Forest Zone	Beyla	Gbackedou	Djakofomdou	3	45
		Guerela	Doubadou		
		Moussadou	Famoya		

Selection of villages and farmers had to pass through official channels because in the present environment, communities are uncomfortable with strangers arriving unannounced. The research team went to the *Prefet* and *Sous-Prefet* in every zone to request permission to work in the zone, and request that a local extension agent from the *Direction Nationale d'Agriculture* guide the team to selected villages to make the proper introductions. In the first week, the research team insisted that they select the villages

in the interest of randomization. The state officials reluctantly complied, and on one occasion, in route to the village, the extension agent advised the team to pull over and stock up on sanitary materials because they selected a village that was rumored to harbor people with Ebola. The team promptly selected a new village, and adopted a new policy of selecting villages in concert with local officials. For this reason, the household level survey does not include villages rumored to have Ebola, but does include as diverse villages as was possible at the time.

Once in the village, the research team and extension agent would explain to the local leadership the goal of the research, highlighting that this was a national survey that would in no way lead to any personal gain or project resources. The leaders were asked to select men, women and youth who engage in some type of horticultural production, from wealthier households and poorer households, from all corners of the village. In every village, the leaders were asked to explain their criteria for identifying people in the two wealth categories. They indicated that the quantity of the household's productive assets (arable land and agricultural equipment) were the main factor in determining a household's status. The survey respondents were asked the same question, and they invariably responded in the same manner, adding purchasing power (resulting from productive assets), household size (resulting from and contributing to productive assets), and remittances[1] (largely invested in more productive assets) as other proxies for determining a household's relative wealth.

In addition to the farmer surveys, male and female village leaders were also asked to participate in a focus group discussion on community-level horticultural constraints and opportunities with the extension agent and the lead researcher. The focus group discussions included 75 village leaders who participated.

The farmer survey had six main components (see Appendix A for complete survey):

- Household profile – size, ethnicity, education and wealth category (household was defined as the nuclear family)
- Household consumption – portion produced vs. purchased
- Production system – hectares of farmed land, and (for horticultural crops) varieties, inputs, major constraints, production and postharvest practices,
- Market engagement – value added to harvest and portions sold
- Household assets – productive and consumptive assets and criteria of wealth
- Social capital – group membership and access to credit, savings and information

The goal of the survey was to understand the farmer segmentation and priorities, categorized by gender and market engagement while highlighting key assets, constraints and development opportunities.

The survey was conducted as a rapid assessment. The sample size was not sufficiently robust to yield statistically significant results. Consequently, the results and discussion will focus on qualitative data that reached a level of saturation among the respondents. For example, except for one village, all respondents said that labor and equipment were their major constraint, while land is plentiful. In the Results and Discussion section, averages and percentages are primarily used to indicate the overwhelming majority of respondents. Any use of these numbers for more subtle distinctions should be approached carefully.[2]

The data in the results section are disaggregated by Livelihood Zone, gender, landholdings and wealth. The relative wealth of households was determined by the new value of their productive and consumptive household assets. While the research team was not able to conduct an exhaustive survey of all household assets, they used focus groups to identify a list of 19 key assets[3] that are used or desired by most rural households, thereby avoiding an indication of preference.

1 Bigger households have more emigrant workers (going to other villages, cities or even abroad), thus contributing to the virtuous cycle between wealth and household size.

2 The Law of Small Numbers warns against drawing hasty conclusions from small sample sizes due to greater likelihood of variation from the true mean, (Kahneman, 2011).

3 Cell phone, motorcycle, bicycle, television, radio, solar panel, personal weekly tea and sugar expenditure, plow, sewing machine, hoe, shovel, axe, machete, donkey cart, donkey, cattle, goats, sheep, chickens (and other birds).

Table 3. Villages and institutions targeted by the stakeholder assessment conducted in August 2015.

Itinerary	Other sites included	Meetings
Conakry	Kipé, Kaloum, Kipé	IRAG, DNA, DNSA, WFP, USAID, UNICEF, WHO
Conakry - Forécariah - Kindia	Kondéyah, Foulayah	DMR, Coop., FABIK, CRAF
Kindia Ville	Foulayah, CU Kindia	RGTA, Kanya, KDF
Kindia - Mamou	Kilissi, Linsan, CU Mamou, Soumbalako	Coop., Retailers, CRAK
Mamou - Dalaba - Mamou	Sébhory, Dounkimanya, Tolo	ENAE, ISAD, Coop.
Mamou - Dabola - Kankan	CU Dabola, Quartier Bordo, CU Kankan	DMR, COOPRAKAM
Kankan Ville	Quartier Bordo	DMR, Coop., CRAB, ENA
Kankan - Kérouané - Beyla	Nyonsomoridou, Bousankoro	DMR, Coop.
Beyla - Macenta - Kissidougou	Kouankan	DMR, Coop.
Kissidougou - Faranah - Mamou	CU Faranah	DMR, Coop., ISAV
Mamou Ville		DMR, Coop.

STAKEHOLDER ASSESSMENT METHODOLOGY

A stakeholder assessment was carried out over an 11-day period in August 2015 (table 3). The assessment targeted the main horticultural stakeholders working in government agencies (research, universities and departments), NGOs, farmer cooperatives (*groupements* and/or *unions*) and high-achieving individual farmers. The assessment consisted of one-on-one surveys, group interviews or discussions, field observations, reading reports and making phone calls. Through this process more than 50 people were interviewed and 15 gardening fields and conservation or processing facilities were visited from Conakry to Beyla. The aim was to collect data from multiple and diversified sources, meet with actors from at the grassroots level, observe ongoing activities and make recommendations for improvement. In particular, this aspect of the rapid assessment sought to:

1. Analyze the horticultural seed systems and opportunities for development, including formal and non-formal systems.
2. Propose a suite of appropriate fruit and vegetable production practices and technologies, including postharvest technologies and infrastructure available to smallholders, citing recent innovations in the sector and the interventions of donors, research stations and NGOs.
3. Identify and interview key governmental, non-governmental and private sector partners in vegetable production and trade in Guinea.

MARKET ASSESSMENT METHODOLOGY

A market survey was conducted over two weeks in August 2015. First, a Guinean geographic information systems (GIS) specialist investigated markets in the greater Conakry area before traveling to Beyla. He surveyed market traders (see Appendix B for complete survey). Due to time constraints, our team enlisted regional NGOs to gather similar data using the same survey. The market trader survey analyzes five categories of traders: wholesalers, wholesalers who also sell retail, retailers, those who transport horticultural products, and shopkeepers. The survey assessed market accessibility, the use of credit, produce losses in the markets, purchasing strategies, market cycles, horticultural suppliers, and contracts along with demographic information about the age, experience, and education of those surveyed. In total, our team surveyed 267 market actors (table 4).

Table 4. Market actors surveyed in the market assessment conducted in August and September 2015.

Locality	Number of market actors surveyed
Conakry	25
Coyah	5
Dubreka	5
Forécariah	10
Faranah	140
Kérouané	23
Beyla	59
Total	267

All data were collected by a U.S.-based GIS and marketing specialist from West Africa and analyzed for commonalities and to identify market needs and opportunities for donor investment.

RESULTS AND DISCUSSION

FARMER AND VILLAGE LEADER ASSESSMENT OF THE HORTICULTURE SECTOR IN GUINEA

Small-scale agriculture in the four Livelihood Zones is subsistence-based[4] and focused on rice production. Of the 190 smallholder farmers surveyed, they collectively devoted 637 hectares to cereal production (372 of which was rice production) and only 231 hectares to horticultural production.[5] A man farmer's primary responsibility is to grow enough grain to meet his family's caloric needs. A woman's responsibility is to contribute to subsistence grain production and independently grow cash crops, which can include horticultural production to help meet household expenditures, such as foodstuffs, healthcare-related costs, school fees and everyday purchases. The more well-off farmers will sell their surplus if they are confident they have enough grain to provide for the year. Worse-off farmers will sell their grain (even though they will have to buy grain later) when financial exigencies arise, such as emergency health costs, school fees, productive asset repair or social ceremonies.

HORTICULTURAL PRODUCTION

In Guinea a smallholder farmer faces a number of constraints—including labor, agricultural equipment, inputs, and mechanization, and unpredictable weather—so he or she makes strategic decisions to maximize the pay-off in achieving food security first and financial security second. Compared to horticultural crops, cereals are generally hardier and, more importantly, easier to conserve for long periods of time. Cereals, mainly rice, are the foundation of subsistence agriculture in Guinea. The farmers surveyed here devoted small amounts of land and assets to horticultural production (table 5). This small amount is based on a farmer's ability to grow vegetables and tolerate risks related to the quantity of cereals produced. Horticultural crops can be more profitable if the constraints work in their favor and everything goes according to plan, but horticultural crops are also more vulnerable to those constraints as well as harder to conserve. Cereals are the stalwarts whose production is more predictable and that in the end feeds the family.

Table 5. Investment of land and assets to producing horticultural crops based on a survey of 190 smallholders in June 2015.

		Cereal hectares	Horticulture hectares	Percentage of hectares devoted to horticulture
Livelihood Zone	GN02	3.2	1.7	35%
	GN03	2.5	1.1	31%
	GN09	3.3	1	23%
	GN10	4.2	1.2	22%
Sex	Male	4.1	1.3	24%
	Female	2.7	1.1	29%
Household Wealth	Wealthier	4.5	1.4	24%
	Middle	3.3	1.3	28%
	Poor	2.9	1	25%
	Poorest	2.5	1.1	31%
Farm Size	>6 Ha	7.3	1.7	19%
	4-6 Ha	3.5	1.5	29%
	2-4 Ha	2	1.1	35%
	<2 Ha	0.8	0.3	27%

In the focus groups, farmers indicated that women grow a higher percentage of cash crops compared to men because women have less responsibility for the households cereal supply and more responsibility for the household's day-to-day expenditures. This is only mildly apparent in the survey data, and could be due to Guinean farmers' poor estimation of the size of their fields. On average, when compared to women, men are farming an extra hectare of rice. Men farm, on average, 1.4 more hectares than women and the data indicate that the extra hectare is devoted to rice production (table 5).

4 A neat division between cash crops and subsistence crops is not possible because most households are selling a small portion of their subsistence crops (millet, rice, sorghum, peanuts, cowpea, corn, sesame). Therefore, this study uses a broad definition of subsistence crops, including all of those, as most households are consuming most of their harvest.

5 Smallholder Guinean farmers lack the means to accurately measure their scattered and misshapen fields. Furthermore, tree crops typically are not planted with standardized spacing and hence are not conceptualized in terms of space. These numbers are rough indicators.

Despite differences in topography, agro-ecological conditions and population density among the four Livelihood Zones, farmers in these zones are cultivating similar amounts of cereals and horticultural products on average. Smallholders in zone GN03 are largely of the Fulani ethnicity. They focus more on livestock than growers in the other zones. They farm less cereal (but equal amounts of fruits and vegetables) as a consequence. Another noticeable phenomenon in the Livelihood Zone section of the data is the decreased percentage of hectares used for horticulture as one travels away from Conakry. Farmers in GN02 and GN03 rent cars and transport their harvest to the bustling markets of Conakry, where prices are higher, while farmers in GN09 and GN10 are relegated to regional markets (discussed in more detail below).

PESTICIDES USED IN GUINEA

" Herbicides are used most on rice, maize, sugarcane, banana, pineapple, coffee, groundnut, and cocoa. Insecticides are used for market gardening of vegetables, citrus, tree crops, coffee, cotton, banana, stored pests, oil palm, tobacco and ectoparasites of livestock. Fungicides are used for seed treatments, market gardening, tree crops, citrus, oil palm, rice, cashew, pineapple, coffee, banana, and cocoa. Rodenticides are both sold by the major pesticide sellers, and were found for sale in small rodent-edible bags with labels in the open market in Conakry. Molluscicides, plant growth regulators, and phosgene gas pellets for stored grain pests round out the available products and uses in Guinea." (Schroeder & Soumah, 2005)

A second calculation made by smallholders concerns labor and input allocation amongst the given array of cereal and horticultural crops. Farmers use more fertilizers and pesticides in fields planted with better varieties and they generally plant their better varieties in fields close to the village because: (1) weeding, guarding crops and hauling organic fertilizer are easier when the fields are close; and (2) closer fields have a higher soil fertility due to a greater concentration of animals and manure from animals returning to the village each night.

CONSTRAINTS TO INCREASED HORTICULTURAL PRODUCTION

Access to arable land is generally not a constraint for Guinean farmers. Except in one village that was tightly packed amongst other villages, none of the respondents indicated that land is an issue. Furthermore, when asked to describe the difference between wealthy and poor people in their village, none of the respondents mentioned arable landholdings; 64 percent said that wealthy farmers can afford to hire labor, 39 percent said that the wealthy can afford more equipment, and 13 percent said that the wealthy can afford more inputs. When farmers were asked what prevents them from increasing production and separately what prevents them from devoting more land to horticultural production, again land was not mentioned. Labor, followed by lack of agricultural inputs, were the major constraints (table 6[6]).

Table 6. Constraints to increasing horticultural production identified by farmers in a survey of 190 smallholders in June 2015.

Constraint	Relative Power[6]
Labor	113
Fertilizer	95
Money / credit	89
Seeds / saplings	87
Pesticides	79
Equipment	54
Motorized pumps	38
Postharvest losses	24

According to those surveyed, the primary constraints to increasing production are labor[7] and access to capital to invest in agricultural inputs and equipment. The labor problem is inherently linked to the lack of capital, inputs and equipment because labor is the productive asset that farmers employ to countervail other shortages. Rather than use mechanized irrigation systems, poor farmers pull water one watering can at a time and irrigate their dry-season vegetables by hand. Rather than using herbicides or tillers, poor farmers weed by hand. Rather than using chemical fertilizer, poor farmers collect manure and haul it out to their fields, sometimes in donkey carts, sometimes in an old bucket on their heads. When Guinean farmers are asked to describe the characteristics

6 Relative power was calculated by reversing rank with points (as 8th was the lowest ranked constraint, the No. 1 rank became 8 points, the No. 2 rank became 7 points, etc.). Total points for each constraint were summed, divided by the total points of all constraints combined, and multiplied by 100.

7 Labor is the main constraint during the agricultural season, but not for the whole year. Composting is laborious (digging the pits, filling them with manure, straw and other materials, watering the pits) but this labor occurs during the dry season, making it a viable option for improving soil fertility.

of wealthy households in their village, they point to the large families, where labor is abundant and where wealth and household size feed off each other in virtuous cycles. While inputs are purchased at the individual level within a household (the wife buys fertilizer and pesticides for her fields and the husband buys for his), agricultural equipment and other productive assets are often shared within a household. Larger households have more labor (the productive asset used to overcome other shortages), allowing them greater flexibility and investment in shared equipment. Larger households also have more emigrant workers (going to other villages, cities or even abroad and sending money back), furthering the positive feedback loops in income generation. The data from the surveys bear out this connection between wealth, household size and labor (table 7).

Table 7. Household size and wealth. Wealth was determined by the total assets, productive and non-productive, owned by the respondent and other household members in a survey of 190 smallholders in June 2015.

	Member total	Members of working age
Wealthier	14.1	7.8
Middle	12.4	7.0
Poor	10.3	5.5
Poorest	9.3	5.5

Poorer farmers will work their own fields and sell their labor to wealthier neighbors within the village, providing those poorer farmers with an additional source of income. Poor farmers have less access to inputs, irrigation and implements (hoes, shovels, etc.). At a certain point, it appears to become in their best interest to work the fields of wealthier neighbors for earning cash or negotiating other necessities. Also, due to poorer farmers' need for money immediately, they often make decisions that lower their overall profit in exchange for immediate payment. Selling labor rather than working your own fields is a good example of this. Another example that occurs frequently in the area of research is that merchants arrive in a village one month before the mangoes or avocados are ripe to offer cash now for rights to harvest an entire tree. They pay farmers a fraction of the value of the tree's harvest and farmers desperate for cash take the deal.

Table 8. Access to markets based on the furthest typical point of sale based on a survey of 190 smallholders in June 2015.

	Furthest typical point of sale (% of respondents)				
	Conakry	Regional capital	Weekly market	In the village	Average distance (km)
GN02	63	15	20	2	86
GN03	47	13	40	0	182
GN09	3	44	41	12	28
GN10	0	60	40	0	21
Men	24	32	40	5	63
Women	23	41	31	5	67
Wealthier	17	42	29	12	70
Middle	17	38	45	0	32
Poor	30	36	30	5	88
Poorest	32	27	39	2	71

RURAL HOUSEHOLD ECONOMIES AND HORTICULTURE'S ROLE

Men and women smallholders are able to access existing markets for both cereal and horticultural crops. Vibrant local markets for cereals exist at all levels from large cities to small villages. As mentioned above, farmers are frequently engaged in the purchase and sale of cereals, based on their financial needs. Poor families tend to sell when the price is low, immediately following the harvest, because they need cash, and they tend to buy more cereal when the price is high, during the lean season, because they run out of cereal. Meanwhile comparatively wealthy rural families are able to wait to sell more of their cereal harvest when prices are higher.

Men and women smallholders alike have access to horticultural markets. When their harvests are smaller, they take their produce to market via public transportation or motorcycle, either borrowed or rented. When they have a large enough harvest, they rent a car and transport their produce to large city markets as far as 200 kilometers away to sell directly to bulk purchasers.[8] Very few (12 of the 190 respondents) farmers opt to sell their produce in the village, either to middlemen or neighbors.

A farmer's gender or wealth appears to have little influence on their ability to access markets. Farmers in Livelihood Zones GN02 and GN03 are close enough to warrant the trip to the Conakry markets where prices are usually higher, so they tend to transport their produce farther distances than farmers in more distant zones (table 8). According to the data, the poor

8 "They sell these products both wholesale (destined for Conakry) and retail. As a result, it is common to see higher prices on the markets in the production areas (retail markets) that on the main destination market for these products in Conakry," reported one focus group participant.

and poorest farmers are more likely to travel farther to sell their produce for a higher profit. This phenomenon most likely indicates preference (wealthy people could access farther markets too, if they desired) and perceptions of optimal time use.

Horticulture is a high-value and high-investment production system that is aimed primarily at market sales. Guinean farmers invest in their horticultural production when they are confident of the return on their investment. Farmers who are closest to the higher demand and stronger markets of Conakry are also the largest investors in their production systems (table 9). A closer look at the data indicates that the Conakry markets have a greater effect on smallholder investment in horticulture than household wealth, as evidence by the clustered levels of investment among all wealth groups. Greater access to Conakry markets would presumably have the same effect on producers in Livelihood Zones that are farther from the capital. Guinean farmers invest more in their vegetable production than fruit tree production (table 9). Fruit trees are seen more as a fixed investment in land resources than financial resources.

Table 9. Investment of land and assets to horticulture by 190 smallholders surveyed in June 2015.

	Percent (%) engaged in tree production	Percent (%) engaged in vegetable production	Annual ($) investment in pesticides and fertilizers for trees	Annual ($) investment in pesticides and fertilizers for vegetables
GN02	98	100	8	250
GN03	50	81	0	141
GN09	71	76	7	10
GN10	43	93	14	46
Men	77	74	12	121
Women	38	95	4	60
Wealthier	66	87	14	92
Middle	49	81	10	98
Poor	48	91	9	88
Poorest	60	86	3	71
>6 Ha	71	86	19	146
4-6 Ha	56	88	8	84
2-4 Ha	54	89	6	71
<2 Ha	41	75	0	60

Table 10. Rank of importance of income generating opportunities to smallholder households among those surveyed in June 2015 (relative power).

Zone	Horticultural production	Herding	Collecting forest goods	Small commerce	Shop owner	Making charcoal	Fishing
GN02	64	10	8	4	1	3	3
GN03	60	19	12	0	6	1	0
GN09	72	7	12	2	2	3	1
GN10	72	3	4	8	3	3	0

Men and women differ in production priorities and investment capacities (table 9). Men are more engaged in fruit tree production. Men also have more capital than women for vegetable production, even though they are less engaged in the activity (see discussion of gendered production below).

In focus groups and in the surveys, farmers indicated that they generally sell 90 percent of their horticultural harvest. The remaining 10 percent is eaten and given to friends and neighbors during the harvest. Most households can only eat a small percentage of the harvest before it spoils, so they give away more than what they consume, expecting reciprocation when the neighbors harvest.

The profit from the sold horticultural goods pays for basic living expenses. In response to an open-ended question about what they buy with horticultural profits, 70 percent of the farmers mentioned food, 55 percent said school fees for their children, 46 percent mentioned clothes, 44 percent said agricultural inputs and equipment, and another 44 percent mentioned health costs.

Even if it were possible to convince rural populations to sell less and eat more of their horticultural harvest, it is not clear that they would be any better off, because they are currently using horticulture to increase their food security and invest in the future (table 10). Without knowing the nutritional value and exact quantities of food purchased and consumed, it is nearly impossible to determine.

Although very little nutrition training reaches rural farmers (87 percent of respondents have never attended a nutrition training from governmental or NGO programs), the population is aware that fruits and vegetables are good for health, but how much and why is not well understood. In focus groups, the research team asked men and women farmers which is better for their health, a handful of fruits and vegetables or a handful of rice. They typically responded that rice was more important, but the fruits and vegetables were healthier, and they had difficulty explaining why (table 11).

Table 11. Percentage of respondents indicating what it would take to convince them to eat more fruits and vegetables.

	Men	Women
Increased production	30	29
Postharvest conservation	46	28
Nutrition training	1	0
Primary needs met first	26	41

GENDERED HORTICULTURAL PRODUCTION

The focus groups with farmers revealed that men and widows tend to own orchards, while women often farm vegetables. While the survey information revealed that it is generally true that men tend to focus on tree cultivation and women focus on vegetable production, in reality, the division is not neat. Some amount of men grow vegetables in most villages (68 percent of men surveyed grow vegetables in the off season and 54 percent during the rainy season) and 38 percent of women surveyed own at least one tree. When they were asked why the division occurred along gender lines, men and women both stated (in order of importance):

1. "It's just the way it is." In other words, it is cultural.
2. Women don't have the strength to farm trees (planting saplings and clearing land for fire breaks).
3. Women can't wait 3-5 years after planting to harvest; they have immediate financial needs.
4. Forest fires can wipe out orchards and women are more risk averse than men.

While these are very real barriers for women in rural farming communities, they are not insurmountable. First, culturally, although women do not inherit trees, they do own them—just in smaller numbers and usually around their homesteads. In rural Guinea there is no cultural proscription for women regarding tree cultivation. However, planting a tree is akin to laying claim to land, which makes it difficult for women to plant orchards in the fields surrounding the village.

Second, regarding strength, orchards require much less work than vegetables; once the orchards are established, they don't need to be watered, while vegetable gardens need to be watered twice per day. In reality it is not a question of brute strength, but of perception. Woman in rural Guinea who are strong enough to pound millet, chop wood, farm 3 hectares without the aid of machinery, and carry large buckets of water for long distances, could certainly cultivate orchards. When needed, their husbands, brothers and sons could be available to help with tasks such as clearing land and chopping wood.

Third, when it comes to immediate financial needs, a woman's income is critical to a household's food security. This barrier can be overcome through slow adoption rates and development initiatives. Our research shows that even men growers often sell themselves short and take less money up-front for products (including fruit trees) that would give them a higher return if they could just wait longer for the cash. Getting through the financially lean seasons is an issue for many in rural Guinea. Finally regarding risk, women are less risk averse than men in the early adoption of new vegetable varieties, and the economic calculation of risk versus reward is no different for women as it is men, who find tree cultivation well worth the risk.

Table 12. Labor differences among men and women respondents in a survey of 190 smallholders in June 2015.

Questions	Women's responses (%) for their vegetable fields				Men's responses (%) for their vegetable fields			
	I do	My husband	My children	Hired labor	I do	My wives	My children	Hired labor
Who plants	68	2	18	32	73	19	21	21
Who weeds	64	2	20	34	55	49	31	16
Who waters	83	0	23	13	50	47	34	7
Who harvests	59	4	22	34	59	48	26	17
Who sells	82	2	14	1	29	70	6	4
Who controls	85	9	2	0	89	2	0	0

As in many parts of the world the labor and time constraints on women are very real. In addition to time and labor dedicated to productive activities such as those related to agriculture their responsibilities to the household and family should also be considered. In this research we saw that women help their husbands with vegetable cultivation and marketing, while men appear to be absent from the women's fields. Women also rely more on hired labor. A point for further research would be to more about the potential connection between the time women spend in their husbands' fields and their reliance on hired labor for their own fields (table 12).

WHEN BOTH GENDERS GROW VEGETABLES

Bountoualy is a 30-year-old Soussou farmer in the region of Kindia, 115 kilometers from Conakry. She lives in a small village where both men and women grow vegetables and sell their harvest in the grand markets of the capital, where supply is hard-pressed to outstrip demand. She grows onions in small plots around her house, and during the rainy season, she grows 0.25 hectares of chili pepper, 0.25 hectares of tomatoes, and 0.75 hectares of eggplant. She buys roughly $10 in fertilizer and $20 in pesticides for each quarter hectare plot. During the dry season, she grows the same crops in roughly the same proportions; only she doubles her expenditures on fertilizer and halves her expenditures on pesticides. Rainy season crops are grown in rotating fields, where farmers look for specific wild plants that indicate the return of soil fertility, reducing the need for fertilizer. She spends more on pesticides in the rainy season because insects and disease are a greater problem. Furthermore, half of the seeds she plants are certified varieties. Bountoualy can't read and she doesn't understand pesticides, so her husband talks to her about which pesticides she should buy and he applies them with an applicator he borrows from a friend. She supplements her chemical treatments with traditional techniques, such as using ash to reduce insect invasions. He also helps her clear her land in the beginning of the growing season, using a broad-spectrum herbicide and then incorporating the residue. Even with her husband's support, she can be found in her fields every day, for 2 to 6 hours, depending on the season (dry season production is more laborious because she pulls water from the stream and waters her vegetables by hand), sometimes alone, sometimes with her children. Upon harvest, she rents a car, or space in a *camion*, to deliver her produce to the vibrant markets in Conakry, where she sells directly to wholesalers. Vegetable gardening is her most important source of revenue, therefore she finds the money needed to buy fertilizers, certified seeds and pesticides. Her husband helps her with the work that is laborious or hazardous.

Bountoualy next to her home garden, a raised bed of onions.

Kadjiatou is a 27-year-old Camankhé farmer in the region of Beyla, a remote corner of Guinea. She lives in a small village where men have plantations of fruit trees, but take little interest in growing vegetables. The farmers in her village sell their harvest in the regional capital of Beyla, 25 kilometers away, where farmers throughout the region descend at the same times of year with the exact same fruits and vegetables to sell which causes prices to fall. Kadjiatou borrows her husband's hoe to farm (when he is not using it) and she grows half hectares of chili pepper, eggplant and okra in the rainy season. She does not grow vegetables during the dry season, even though she has access to arable land near the local stream. She does not purchase fertilizer or pesticide for her vegetable production, and she does not use improved or certified seeds. She plants saved seeds from the year before. She does not even know where she could find improved seeds. More importantly, she is not certain enough of the market for her harvest to invest in seeds or inputs. She cites a lack of knowledge of pesticide selection and application as a barrier of adoption, and she does not use traditional pest management techniques, such as the application of ash to keep insects away from her horticultural crops. Unlike Bountoualy, Kadjiatou's husband does not grow vegetables; he would not know how to advise her in the use of pesticides or improved seed. During the rainy season, Kadjiatou splits her time between tending her vegetable and her agronomic fields, with cereals taking more importance because her family's food security depends on their ability to grow staple foods. Her vegetable production has widely varying profits from year to year, depending on the caprice of the markets, invading insects, and mysterious plant diseases.

Kadjiatou planting a peanut field along the northern edge of Guineas's remote forest zone.

Aboubacar, a dynamic farmer in Kindia, grows pineapples, bananas, chili pepper, okra, cucumbers, tomatoes, avocado, palm oil, and mango, while experimenting with new varieties of papaya. He advises his wife in many facets of her production, while at the same time acknowledging the advantages that female growers add to his own approach, "You see, women spend more time in the market, selling and buying vegetables. They are the first to recognize the value of new varieties, and the first to experiment with their production. I have seen enough women succeed with the new cucumber variety that I will plant it this upcoming dry season."

Aboubacar surveying his pineapple field

HORTICULTURE CROP PRODUCTION

Horticultural production in Guinea most often takes place in and around the home during the rainy season. Crops can include eggplants, pepper, tomatoes, potatoes, sweet potatoes (mostly in Mamou area), squash or beans. In addition to fruits and vegetables, farmers also grow maize, cassava, and peanut. As discussed above, much of this production is managed by women. Horticultural production in the dry season takes place mostly along river banks or along streams where farmers either work individually or in groups (*groupements, seres,* or *unions*). Farmers also grow various fruit trees intercropped in these fields, mainly citrus, but also mangoes, avocados and bananas.

Some permanent plantations do exist in communities (usually outside villages or cities) where farmers are growing multiple fruit tree species together, including bananas, citrus, mangoes, avocados, or cashew. This horticultural practice is usually done individually and also intended for both family consumption and commercialization (export or local weekly

markets). Very little care or improved management practices are provided to these types of plantations, and species are genetically old and not renewed. Plantations are largely located around Beyla for export of fruit to Côte d`Ivoire (table 13).

Table 13. Major horticultural crops grown in the assessment corridor.

Location	Areas visited	Vegetables grown		Fruit trees
		Rainy Season	Dry Season	
Forecariah	Maferinyah	Eggplants, maize, water melon, okra, cassava	Lettuce, cabbage, pepper, okra, etc.	Mango, avocado, banana, citrus
Kindia	Foulaya, Kindia Ville, Kondeyah, Friguiagbe	Tomato, cassava, onion, eggplant, lettuce, cabbage, okra, maize,	Tomato, sweet potatoes, lettuce, cabbage, eggplants, pepper, carrot, okra, etc.	Mango, avocado, banana, citrus
Mamou	Mamou Ville, Soumbalako	Maize, potatoes, sweet potatoes, lettuce, okra, eggplant, pepper, beans	Tomato, sweet potatoes, lettuce, cabbage, eggplants, pepper, carrot, etc.	Mango, avocado, banana, citrus
Dabola	Dabola Ville	Maize, peanuts, okra, eggplants	Tomatoes, lettuce, cucumber,	Mango, banana
Kankan	Kankan Ville, Bordo, Scierie	Maize, onion, cassava	Lettuce, onion, eggplant, cabbage	Cashew, mango, citrus
Kerouane	Kerouane Ville	Okra, eggplants, maize, pepper, peanuts	Eggplants, onion	Mango, banana
Beyla	Beyla Ville	Okra, eggplants, maize, pepper, cassava,	Eggplants, sweet potato, cassava	Bananas, mango, avocado, citrus
Kissidougou	Kissidougou, Fermessadou	Okra, eggplants, maize, pepper, cassava	Okra, eggplants, sweet potatoes	Banana, mango
Faranah	Faranah Ville	Okra, eggplants, maize, cassava	Okra, eggplants, sweet potatoes	Mango, citrus

Horticultural production is a complex endeavor that is both knowledge- and capital-intensive. To maximize production, farmers need to be able to:

- Identify horticultural crops and varieties that are (1) adapted to their local environment and (2) desirable in the local market, and then successfully conserve the best seeds for the following season.
- Identify (1) the specific insects and diseases that cause damage to their crops and (2) the appropriate pesticides or traditional pest management techniques, and then apply them at the correct dosage, at the correct point in the crop's life cycle, and in a safe manner.
- Discern (1) the soil fertility and (2) the nutritional needs of each horticultural crop, and then apply the correct dosage of organic and chemical fertilizers at the appropriate time.
- Harvest, sort, conserve and transport the fresh produce using techniques that minimize postharvest losses between the field and the market.
- Calculate how much they should invest in each horticultural crop given market uncertainties, and find access to finances or credit to ensure their ability to invest.

These necessities warrant a daunting set of skills for the average illiterate farmer in rural Guinea. In villages where men do not participate in vegetable production, the women are left to figure out all of these issues on their own. The women are less equipped than the men to solve these problems because they are often less educated and thus have much lower literacy rates. In the villages where men do not grow vegetables, women are less likely to apply pesticides and chemical fertilizers, as this is a task normally given to men. These fields often have lower yields, and the female growers make smaller profits from their production. Communities are more prepared to meet these challenges and find success when both men and women are bringing their unique skill sets and experiences to bear.

Vegetable growers are dependent on external markets for seed supplies. Seeds are imported from the neighboring countries of Senegal, Mali or Côte d`Ivoire (depending on the proximity to the production area/community) but also from Europe (France, Belgium or the Netherlands). The biggest importers of improved seeds are in Conakry (*Tidiane Agriculture*) and in Kindia (*Comptoir Agricole*). They work closely with farmer cooperatives and researchers to request conventional materials (seeds, herbicides and pesticides) and respond to local demands. The government doesn't exert control over the importation of seeds resulting in little if any germination or quality testing or technical assistance. The government initiated a seed

Table 14. Importance of horticultural crops by Livelihood Zone, gender, and wealth class from a survey of 190 smallholders in a June 2015 survey.

	Eggplant	Chili pepper	Okra	Tomato	Cassava	Onion	Potato	Avocado	Banana	Cucumber	Mango	Orange	Palm
GN02	6.8	6.7	1.6	3.2	2.1	0.5	0.2	0.0	0.2	1.2	0.0	0.0	0.0
GN03	3.7	2.9	1.6	3.3	0.4	0.1	2.1	0.2	0.2	0.0	0.0	0.2	0.0
GN09	7.3	5.4	4.7	3.0	1.3	2.7	0.0	1.7	1.5	0.2	1.4	1.2	0.8
GN10	6.3	5.1	6.2	1.8	1.0	0.6	0.2	0.3	0.0	0.3	0.3	0.3	0.4
Men	9.2	8.5	4.7	4.1	3.4	0.1	1.1	2.0	1.8	0.6	1.1	1.4	0.9
Women	14.9	11.5	9.4	7.1	1.4	3.8	1.4	0.2	0.1	1.1	0.5	0.2	0.2
Wealthier	6.7	5.1	4.9	2.6	0.7	0.9	0.6	1.2	0.4	0.8	1.2	1.0	0.2
Middle	6.2	5.3	3.3	2.4	1.9	1.5	0.2	0.3	0.6	0.5	0.0	0.1	0.3
Poor	5.6	4.8	2.7	3.0	1.5	0.8	1.0	0.5	0.4	0.3	0.3	0.1	0.4
Poorest	5.5	4.8	3.1	3.2	0.8	0.7	0.6	0.3	0.5	0.1	0.1	0.3	0.2

distribution system in 2012, but this provides untested seeds to uneducated farmers who lack regular technical agricultural assistance. An initiative like this, while a good start, is likely too little too late. Seed distribution schemes without technical follow up or oversight can easily become a hand-out program only benefiting politicians seeking votes. There have been a few programs supported by research centers that have initiated seed production systems locally (Dalaba, Kilissi, Bordo, Foulaya, etc.). So far, little success has come out of these programs, and most rural growers continue to rely on old seeds they can save from previous harvests (see section on institutional capacity for additional information).

Growing vegetables is more laborious and more knowledge- and capital-intensive than managing fruit tree plantations, in part because vegetables require twice-daily watering, most of which is done by hand without any motorization, while trees only require intense care in their first year. Vegetable gardens require constant care, weeding, and pest protection. Men grow vegetables only when they believe it is worth their while, i.e., in villages where it is sufficiently profitable to grow vegetables due to access to reliable markets. Some crops such as eggplant and chili pepper are important across regions, genders and wealth classes (table 14).

Men and women smallholders generally have access to markets and productive land. Women tend to have equal access to markets as men, and women are usually more aware of new varieties because they interact with the market as vendors and consumers.

HORTICULTURAL POSTHARVEST AND PROCESSING

In general, the difference between the fruits and vegetables that are eaten and those that are sold is their ability to be conserved. Two main factors here are (1) the ease of preservation and the physiological nature of the specific crop, and (2) the farmer's ability and access to technology to conserve through drying, cooling or other means. For fruits and vegetables that a household can conserve (mostly by drying), such as okra and chili pepper, the family will consume up to 80 percent of their total production. For fruits and vegetables smallholders cannot conserve, such as tomatoes, it is a race to sell as

OKRA

" Okra is second only to chili pepper in terms of profitability for poor communities, due to high and steady demand in local and urban markets. The main constraints of the sector concern: its extensive farming practices, traditional varieties characterized by low productivity and poor storage conditions, which negatively affect its commercial value. " (USAID, 2006a)

Farmers generally cultivate two varieties of okra, a disease-resistant long-season variety that is intercropped in rice fields and a short-cycle okra (45 days) that is grown in dry-season gardens. Farmers complain that the short-cycle variety is vulnerable to pests, especially insects. They use chemical insecticides and ash to protect the leaves. Okra is an important part of the rural Guinean diet; it is used in sauces to make rice and cassava-based dishes more palatable. Furthermore farmers can dry and store the vegetable and thereby consume or sell it throughout the year. Many farmers sell 90 percent of the short-cycle variety on the day of the harvest to meet immediate income needs. By the time they harvest the long-cycle variety, the price of fresh okra has fallen and so they dry and store it. They report that they eat a much higher percentage of the long-cycle because it is stored in their homes and available for the taking.

much as possible, about 90 percent as soon after harvest as possible (figure 3). To keep these vegetables any longer than one day is to watch hard work and investments rot away.

Besides greater consumption of these conservable vegetables, smallholders also exert greater economic control over their harvest when they are able to preserve it for longer periods of time. After they have covered immediate financial needs, selling either the fresh product or the first harvest, they typically hold their dried okra and chili pepper and sell later at a much higher market price (figure 3). Preservation and storage allows them to more effectively play the market to their advantage, rather than be forced to accept the market prices on the day of the harvest.

Figure 3. Number of respondents who grow and dry common horticultural crops, reported by 190 smallholders surveyed in June 2015.

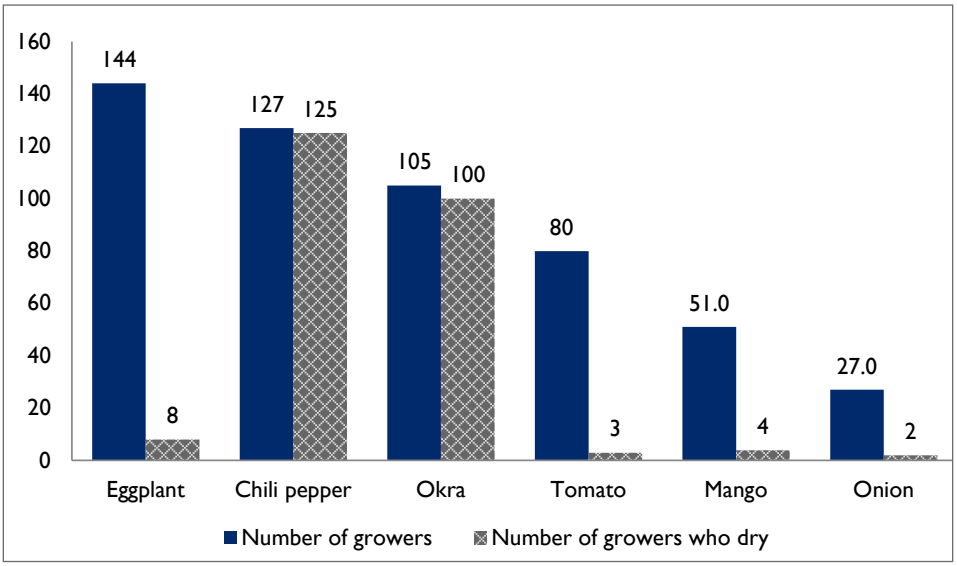


Table 15. Main fruit and vegetable and other major processors in Guinea.

Structure/Organization	Location	Main Activities
COPRAKAM	Dabola	Peanuts
Kanya Nema	Kindia	Fruits and Vegetables
Kanya Donse Fanyi	Kindia	Fruits and Vegetables
COPEFL	Kindia	Fruits
FABIK	Kindia	Fruits and Vegetables
AFTT	Kankan	Fruits and Vegetables

In Guinea, there are food processing and handling facilities operating at a small-scale mostly around cities, such as Kanya Nema, Kanya Donse Fanyi, or *Coopérative des Producteurs et Exportateurs des Fruits et Légumes de Friguiagbé* (COPEFL) near Kindia; *Association des Femmes Techniciennes et Technologues* (AFTT) or *Federazione delle Unioni di orticoltori della Haute Guinée* (FUMA) near Kankan; and *Coopérative des Producteurs d'Arachide de Karité et de Miel* (COPRAKAM) near Dabola (table 15). Most postharvest processing is done in the traditional way using direct sunlight

MANGOES

Farmers throughout the four Livelihood Zones reported that fruit flies attack their trees, and roughly 60 percent of their mangoes rot on the tree before harvest. They generally do not buy pesticides or practice integrated pest management, mostly because supply outstrips demand during the harvest. Many farmers believe mangoes aren't worth taking to market; they invest cash only in crops that generate cash. For Guinean farmers, mangoes are a low-labor, low-investment and low-income-generating crop.

Mangoes are a missed opportunity for horticulture and household nutrition. They are highly productive trees, farmers eat most of the harvest, and they yield at the beginning of the lean season when household incomes and nutrition plummet among the poor. The main problem with mango production is that the whole nation harvests them at the same time and farmers don't have viable postharvest conservation options, creating periods of gross abundance followed by total absence, thus hindering market opportunities. Postharvest options would allow farmers to continue to sell and consume mangoes throughout the lean season. Newer varieties and planting methods could also alter the harvest date to increase the likelihood that mangoes become a viable economic investment.

The secondary problem is the damage caused by insects. A Chemonics assessment of pest management in mangoes recommends smallholders use baited, insecticide-laden traps (Schroeder & Soumah, 2005).

for drying, and firewood for cooking or smoking. Oftentimes recycled (non-food-safe) containers are used to preserve, transport, or sell this dried product. Some processed vegetables or fruits are hard to sell because of cultural or food habits in certain areas. Those processing or selling processed fruits and vegetables can face serious losses (mango, onions, tomatoes, etc.).

While rice is the staple food of Guinea, each meal includes a sauce of vegetables. While some foods are widely acceptable when dried, people interviewed around Kankan (GN09) reported certain reluctance in using processed vegetables for family consumption (like dried onions, mangoes or tomatoes) and having high preference for the commonly used vegetables in their "natural" or unprocessed way. This has stopped some vegetable growers from drying fruits and vegetables even though they know that they could make more income if sold later during the rainy season when these vegetables are scarce.

CHILI PEPPER

Chili pepper is one of the most profitable and widely grown vegetables in Guinea. The main domestic markets for the product are in Conakry, Kindia, Labé, Kankan, and N'Zérékoré, where women bring them for resale from markets throughout the country (USAID & Chemonics, 2006). Focus group participants reported that a 50 kg sack of chili pepper can sell for $21 USD throughout the year while a 50 kg sack of okra sells for roughly $10 USD. Chili pepper is a very popular addition to local dishes, and the varieties are judged by their pungency. Farmers can dry and store it, to sell or eat it another day. Guinean farmers grow local varieties and use saved seeds. They have a variety that yields large fruit, often called Sikouly (named after an insect of similar appearance), and a variety that produces small fruit and can produce 10 times per year for three years. Harvesting the smaller variety is more labor intensive, but it has fewer disease issues and it is more attractive to consumers because it is spicier. These chilies have export potential as well. In Senegalese markets, they are known for their high pungency, referred to as the "little Guinea pepper," but pepper producers from Benin, Nigeria and Burkina Faso who use better production and postharvest practices (homogeneity and plastic packaging) make for strong competition (USAID, 2006d).

If smallholders could add mangoes, avocado, bananas, tomatoes or eggplants to the list of products they can process and store, it is clear they would increase their bargaining power and increase profit. The increase in profit would allow them to invest in their production, household needs, technology, and foodstuffs as they see fit. Households would also eat more of these fruits and vegetables if they could save them, improving the diversity of their diets. The farmers in the focus groups said that fluctuations in production didn't change the amount they ate because the amount of fresh product they set aside for production is constrained by what they can consume (or choose to share) before it rots. Larger harvests have no effect on that constraint (table 16).

BANANAS

An improved banana variety, Feya, costs $0.35 USD per mature corm. Other costs for banana production include fungicide, manure, fertilizer and potassium, adding up to about $2.20 USD per tree. A Feya plant can produce up to about 60 kilograms in its lifetime. Farmers sell bananas for $0.50 – $0.90 per kg. So for about $2.55 USD invested per plant, these plants can generate upwards of $50 USD. More importantly, farmers eat large portions of their banana harvest, and bananas do not necessarily follow a season in Guinea. This allows farmers to strategically plant bananas nine months before they believe the market price will be high, to schedule their harvest accordingly. They often plant at the start of the rainy season so that the yield occurs during the dry season (but before mango season, which lowers the price of bananas). Bananas also have export potential in West Africa; 34 percent of bananas grown in West Africa in 2010 were exported (FAO STAT, 2015).

Table 16. Percentage of respondents answering the question "What would you do if you doubled your production?" in a survey of smallholders in June 2015.

	Sell less, eat more	No change	No change because there's no postharvest
Men	22	60	17
Women	41	36	22

Guinea has very few horticultural canning factories, and it is our estimate that in the four Livelihood Zones there are fewer than 10 functioning ones. Even if Guinea could muster the political will, market access, management capacity and finances to modernize or expand these facilities, the smallholders supplying them would still be price-takers, and they would be investing their production capacity into finicky markets beyond their comprehension, without the flexibility to do anything but sell the day they harvest. It would be good to look to successful examples in other countries in the region to see how these processing opportunities can be both safe and successful for local consumers and profitable and empowering to local growers.

HUMAN AND INSTITUTIONAL CAPACITY ASSESSMENT OF THE HORTICULTURE SECTOR IN GUINEA

AGRICULTURAL RESEARCH AND DEVELOPMENT

Over the last five years, Guinean agricultural research and development spending levels have gradually increased due to increased government support. Along with increased support, the number of agricultural researchers has also increased. Still, two-thirds of Guinea's researchers hold just a Bachelors of Science degree. The largest Guinean research agency, I*nstitut de Recherche Agronomique de Guinée* (IRAG) is expected to lose 90 percent of its Ph.D. researchers by 2023 due to age and retirement. This highlights an urgent need for training in agriculture (ASTI, 2015). This also means that appropriate financial resources need to be dedicated to retain a young and dedicated workforce. As in much of the world, women researchers in Guinea make up a fraction of the research community, with only 4 percent of agricultural researchers being women. Programs such as African Women in Agricultural Research and Development (AWARD) are working to increase opportunities for women in science, but efforts need to be started early in girls' education. Education for girls from primary through university levels should encourage girls and women to engage in the sciences.

In 2011, Guinea invested just 0.22 percent of its agricultural GDP in research and development, much less than the levels recommended by the New Partnership for Africa's Development (NEPAD) and the UN of 1 percent GDP. In terms of the

number of researchers per 100,000 farmers, Guinea (7) does slightly better than its neighbors Liberia (5) and Sierra Leone (6).

Overall Guinea's agricultural research portfolio is balanced between crops (57%), livestock (13%) and fisheries (7%). Within crop research, most researchers focus on rice (23%) with fewer researchers focused on vegetables, cassava, maize, bananas and plantains (about 12% each) and other fruits (6%). This clearly reflects the importance of rice to the national economy and also the low prioritization of vegetable production among researchers.

In Guinea there are eight public agencies conducting agricultural research and development (table 17). IRAG accounts for more than 60 percent of the country's agricultural researchers. The institute focuses on a range of research topics, including crops, livestock, natural resources, postharvest issues, and agricultural engineering. Currently there are no private nonprofit nor for-profit organizations conducting agricultural research and development in Guinea (see Appendix C for key stakeholders in Guinean horticulture including government, non-government, and private stakeholders).

Table 17. Research centers in Guinea.

Name of Center	Location	Specialties
Institut de Recherche Agronomique de Guinée (IRAG)	Conakry	Supervision of different research centers and coordination of research projects
Centre Régional de Recherche Agricole de Foulayah (CRRAF)	Foulaya, Kindia	Fruits and vegetables
Centre Régional de Recherche Agricole de Bordo (CRRAB)	Bordo, Kankan	Fruits and vegetables
Centre Régional de Recherche Agricole de Seredou (CRRAS)	Seredou, Macenta	Fruit trees
Centre Régional de Recherche Agricole de Bareng (CRRAB)	Timbi Madina, Pita	Vegetables
Centre de Recherche Agricole de Kilissi	Kilissi, Kindia	Rice, legumes, variety selection, research and extension
Centre de Recherche Agricole de Koba	École Nationales d'Agriculture et d'Élevage (ENAE), Koba, Boffa	Swamp rice production

DEFINITIONS OF GUINEAN FARMER GROUPS

Groupement: Mostly composed of women, groupements are often a group of tens of farmers working together to grow vegetables. They usually have official recognition papers, work in larger fields, and are organized from production to sales. They are provided with technical assistance by either the government or local NGOs.

Union: A union is a group of many groupements where people work with and support each other in a prefecture or administrative region. Unions defend groupements' sovereignty and facilitate supply or sales locally and internationally.

Federations: Federations are larger entities gathering many unions together and are usually specialized in one value chain. Federations are commonly on a regional level and contribute highly to trainings, technical and financial assistance through loans. They also defend unions' sovereignty and facilitate networking within the country or with potential partners abroad.

AGRICULTURAL EDUCATION AND TRAINING

Guinea has two universities and four professional schools teaching agriculture. Curricula vary from three years in professional schools to four years in universities where very recently postgraduate courses have been initiated, i.e. *Institut supérieur agronomique et vétérinaire* (ISAV). Few graduating students are taken each year to agricultural research centers or NGOs for practical and hands-on trainings. Research centers used to provide the extension service, *Agence Nationale de la Promotion Rurale et du Conseil Agricole* (ANPROCA) with up-to-date information to deliver to farmers. However, now most research centers test seeds and work directly with farmers instead of working with ANPROCA. NGOs also play an important role in extension across Guinea even though they are facing their own multiple challenges. In one of the assessment corridor zones (GN03), the National Horticulture Promotion Center in Dalaba provides training and technical assistance to many producers across the country.

The presence of cooperatives in the country cannot be underestimated. Being part of an association or cooperative is commonplace and often advantageous (as described in the marketing section). In Guinea, farmers are organized into *groupements*, *unions*, and *federations*.

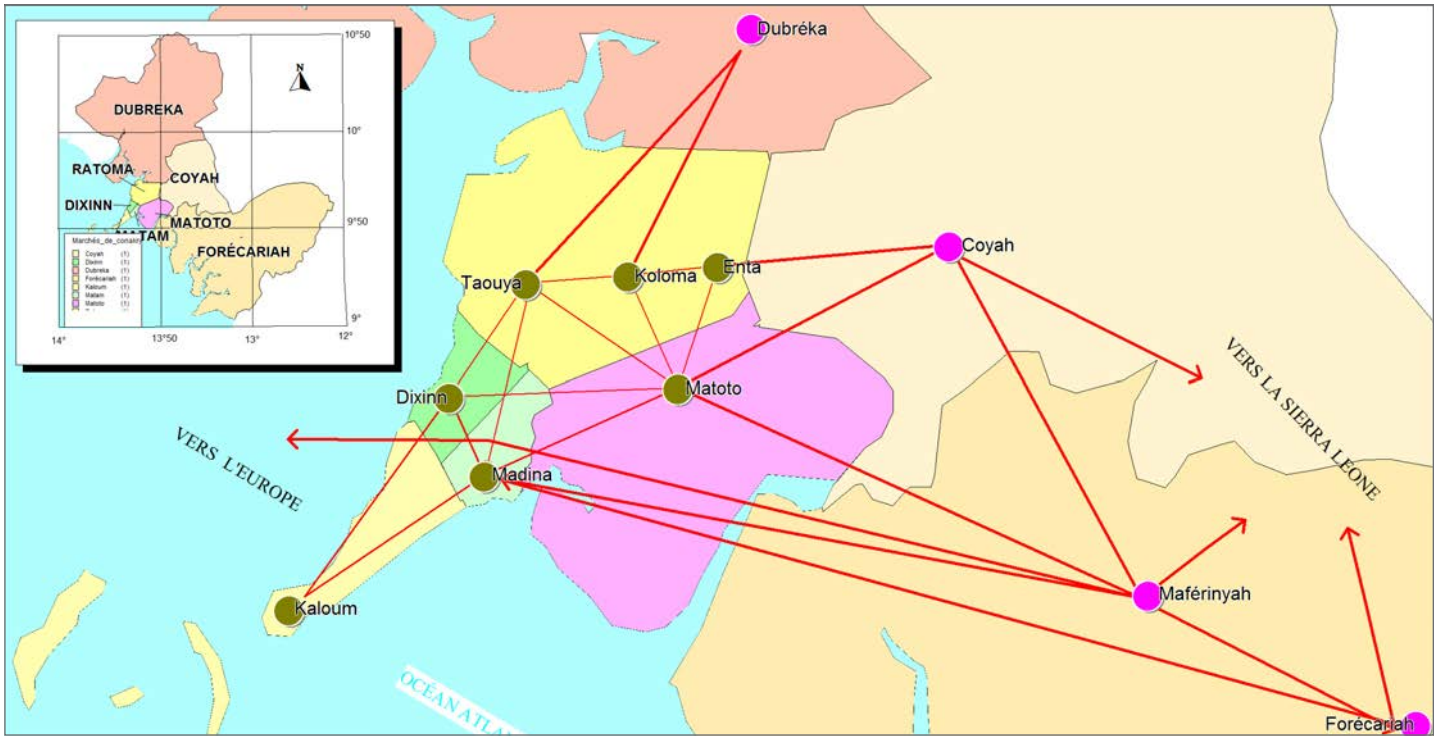


Figure 4. Market routes in the Conakry metropolitan area. Bah A. Pita, 2015.

MARKET AND TRADE ASSESSMENT OF THE HORTICULTURE SECTOR IN GUINEA

The horticultural marketing network in Guinea is mainly a short circuit between the collection areas in countryside and distribution markets in urban centers. In large cities such as Conakry and the regional capitals (such as Labé, Kankan and Kindia), markets operate daily. In rural areas markets take place on a weekly basis. Increases in market garden production and development of road infrastructure as well as improving in transport conditions have contributed to greater business activity with the arrival of new actors at different levels of the value chain (production, transport, distribution). This market and trade assessment took place in all four Livelihood Zones (table 18).

Overall, the assessment found that women are more numerous than men in the market sector, representing up to 77 percent of the market players. This is particularly true within cities. Generally products, mainly potato and onion, are packaged 50 kilogram bags or in baskets of various sizes (as is the case with tomato, eggplant, and okra). Yam, pineapple and other fruit are priced per unit. The trade of ornamentals is an embryonic activity in Guinea, although one can find small flower shops in large cities destined for homes and public spaces.

Table 18. Markets surveyed by the Horticulture Innovation Lab in August and September 2015.

Préfecture	Livelihood Zone	Market Place
Conakry	GN01	Matoto
		Enta
		Madina
		Ko
		Taouya
Dubréka	GN02	Dubréka
Coyah		Coyah
Forecariah		Central Forecariah
		Maferinyah
Faranah	GN09	Marella
		Sandenia
		Kalia
		Soulemania
		Tiro
		Bagna
Kerouane		Konsankoro
Beyla	GN10	Moribadou
		Marché de Yentèdou
		Kissiboula

MARKETS IN THE CONAKRY METROPOLITAN AREA

Within the city of Conakry there are five main areas: Kaloun, Dixinn, Ratoma, Matoto, and Matam. In these areas, Matoto, Madiana, Kolama, Taouyah, and Enta are the main markets in Conakry (figure 4). The Matoto and Enta markets are in the town of Matoto along National Highway No. 1. The Madina market is the largest in the metropolitan area. The Niger Road provides the main access to the market. The Kolama and Taouyah markets are in the town of Ratoma. The Koloma market is at the edge of the Prince Road and the Taouyah market is along the North Ridge of the town. The main collection places for horticultural produce destined for Conakry markets are in

Dubréka and Coyah. In these two markets, the main products are cassava and sweet potatoes. The Forecariah-regional Maférinyah market is a collection center of pineapple and watermelon, depending on the season. A pineapple juicing facility exists here for pineapple juice export to Europe.

MARKETS OUTSIDE CONAKRY

In markets outside of Conakry that were surveyed in August 2015, we found fruits and vegetables in half of the market stalls. Pineapple, avocado, guava, and mango were the dominant fruits while tomato, eggplant, carrot, cabbage and lettuce where the most common vegetables. At the time, 20 percent of all market stalls had chili pepper. While markets in the greater Conakry metropolitan area and in Faranah had a diverse amount of products including tubers, fruits and vegetables, a higher percentage of vegetables were found in markets around Beyla.

MARKET ACTORS IN GUINEA

As discussed above, the trade of horticultural products in Guinea is dominated by women. Of the market actors surveyed, the majority were Muslim and on average, 37 years old. These women had an average of six children to care for who helped them in their business. One-fifth of the traders have a second home in the metropolitan area that gives them control over both urban markets and rural production supply chains. Most (80%) marketed a variety of produce instead of specializing in one aspect of the market segment. These traders had been working in the markets for nine years, on average. Nearly one-third of traders surveyed had another job before engaging in the trade of horticultural products. To finance their business, most traders used their personal savings (44%). One-quarter of the respondents received funding for their business from a family member, while 18 percent received money for the business from their husband. Very few were able to receive a bank loan.

Table 19. Perceptions of horticultural production traders with regard to services provided by organizations in a survey of traders in the Conakry metropolitan area.

	Entirely satisfied	Satisfied	Little bit satisfied	Very disappointed	Little bit disappointed	No opinion
Organization functioning	51	9	0	0	0	40
Sale space management	31	42	8	11	0	9
Security	11	64	0	9	11	4
Cleaning	0	15	0	22	26	29
Pricing	7	67	0	7	0	13
Taxes	0	69	0	8	8	11
Relationship with public administration	0	11	0	2	0	80

Association membership is quite strong among horticultural produce traders in this part of Guinea where the majority were a member of at least one organization (either an association or a savings group). Traders were members of these associations because of the services offered by them as was indicated by our survey of human and institutional capacity. Services offered by the associations were the negotiations of sales stalls and security and cleaning of those stalls (table 19).

Over half of the respondents experienced a period of supply disruption. Sometimes, this period could last up to one year. To reduce the risk of this happening, most of the traders establish a link to suppliers, giving the suppliers money in advance to guarantee their supply. This is particularly true during harvest. Trust between horticultural produce traders and their suppliers is reciprocal. To transport goods from rural to urban areas, traders used taxis or rented vehicles.

MARKET STORAGE ISSUES

Almost half of the traders surveyed had no warehouses to store their products in their markets in Conakry as well as in the inland cities of Faranah, Kerouane, or Beyla. As is the case in many West African cities, markets take place in outdoor areas, under the sun, with little access to clean water or clean surfaces to work on. In some cases, traders in Guinea sell produce directly from their vehicles. As is expected, market conditions like this result in poor food safety and high postharvest losses. Because traders cannot store leftover produce, the produce that is unsold is given away at the market (80%). This

food is given with promise of payment that rarely comes. An estimated 18 percent of the leftover produce is taken home and the remaining 2 percent is destroyed.

TRANSPORTATION

In discussions with traders, we found that prices fluctuate seasonally in part because of road conditions. During the rainy season, roads significantly deteriorate. In addition to poor road conditions, transportation in Guinea is complicated by the fact that (1) the freight sector is not integrated into the agricultural marketing sector, (2) there is no specialized agricultural transportation company, and (3) transportation of food products is not highly structured. Food transportation tariffs are not regulated so the risk of price distortion is high.

Guinea has a road network of 6,825 kilometers, of which approximately 1,979 are paved. The road network is severely degraded and poorly developed. The road network is not adequate for today's population and village distribution. Markets are located very far from each other (table 20).

Table 20. Distance between areas of production and markets for horticultural products in Guinea.

	Conakry	Kindia	Mamou	Faranah	Kissidougou	Kerouane	Beyla
Conakry	0	113	245	431	572	728	837
Kindia	113	0	135	320	462	617	724
Mamou	245	135	0	187	328	484	590
Faranah	431	320	187	0	143	298	405
Kissidougou	572	462	328	143	0	161	267
Kerouane	728	617	484	298	161	0	108
Beyla	837	724	590	405	267	108	0

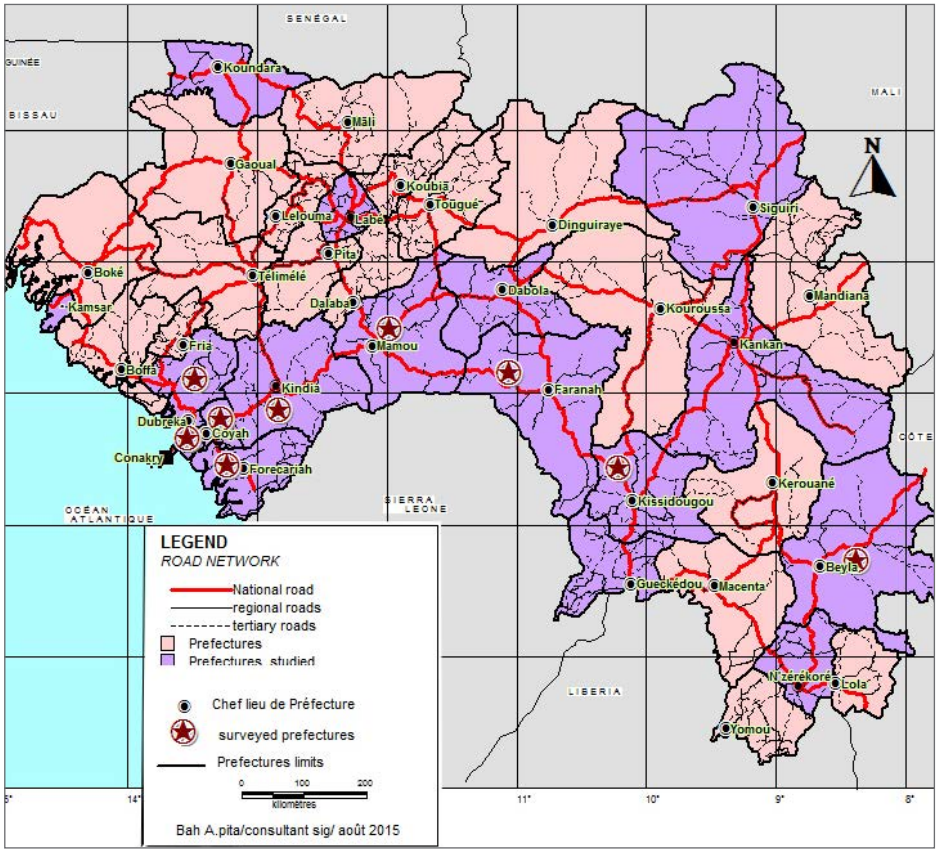


Figure 5. Map of the Guinea road network. Bah A. Pita, 2015.

While transportation costs may not be the only determining factor of seasonal price fluctuations, they are a major constraint to the marketing of horticultural produce in Guinea. The age of the vehicle fleet, the disorganized national transportation system and the poor state of the roads are major constraints (figure 5). Transport companies don't exist which requires farmers to move their produce to the markets on their own by bus, taxi, personal car or rented/borrowed vehicle. Traders who were surveyed indicated that this is a constraint for them. Perishable fruits and vegetables don't fare well with the existing transportation constraints.

MARKETING CHANNELS AND REGULATION OF HORTICULTURAL CROPS IN SOUTHERN GUINEA

Agricultural marketing issues in Africa are not exclusively in the realm of markets or traders, but also an important aspect of governance of the sector. Traders and farmers do have a high level of self-governance through the use of *groupements, unions,* and *federations*. The role of these organizations and the traders' associations is integral to the horticultural marketing sector.

NUTRITION AND HORTICULTURE IN GUINEA

In Guinea the overall status of nutrition, especially for children is grim. Malnutrition is one of the most important social, health and economic problems for this small, densely populated nation. Very few gains have been made over the last 10 years, and children within all sub-groups have relatively high levels of stunting (36%), and a lack of dietary diversity. The only child health indicator that has improved according to the 2012 Demographic Health Survey (DHS) was the percentage of underweight children under 5 years of age. Poor feeding practices affect the quality and quantity of foods provided to children, as well as the timing of their introduction. Lack of prenatal care for mothers and primary healthcare for children compound consumption-related deficiencies. Poor sanitation puts young children and expectant mothers at increased risk of illness, in particular diarrheal disease, which adversely affects and compounds their nutritional status. These three factors—poor healthcare infrastructure and services, inadequate food supply and intake, and poor environmental sanitation—reflect underlying social and economic conditions that result in poor nutrition for all, especially the most vulnerable.

ACCESS TO PRIMARY HEALTH CARE SERVICES.

In 1987, Guinea adopted the Bamako Initiative which recognized the principles of comprehensive primary healthcare. In its implementation, Guinea began to transfer the management of health care services to community health committees, empowering them to provide a cost-effective basic package of health care in rural areas (DHS, 2012). Significant challenges remain. Slow progress to improve indicators such as under-five mortality (DHS, 2012) and under-five stunting (UNICEF, 2012; World Bank, 2014) show that Guinea continues to struggle to provide access to primary healthcare services to the most vulnerable.

ACCESS TO SAFE AND NUTRITIOUS FOODS

The prevalence of women with low body mass index (BMI) has changed little between DHS surveys in 2005 and 2012, from 12.7 percent to 12.3 percent. In fact, among women in the poorest wealth group, the prevalence of low BMI has significantly increased (DHS, 2012). According to FAO between 1991 and 2014, Guinea produced enough fruits and vegetables to meet the recommended 400 grams per person per day for the prevention of chronic diseases. However, these data do not consider access to safe and nutritious fruits and vegetables, or related social determinants. These data are also highly inconsistent with other indicators related to actual consumption, stunting and wasting. This could and often does lead to the assumption that caloric deficiencies (rather than micronutrient ones) are to blame for high levels of stunting.

ACCESS TO CLEAN WATER AND SANITATION

Over 60 percent of Guineans have access to some type of improved water source, while 19 percent are getting drinking water from unimproved sources or surface water (IFPRI, 2014). While access to and use of improved or shared sanitation facilities have been improving over the last 25 years, increasing from 20 percent to 40 percent, around 60 percent of the population still has no or little access to safe and clean sanitation facilities (IFPRI, 2014). While some infrastructure improvements have been made, the prevalence of diarrhea in children under five has remained constant at 16 percent between 2005 and 2012 DHS surveys.

CURRENT STRATEGIES

These high rates of malnutrition throughout Guinea pose major social and economic challenges for this small West African country. The government of Guinea has responded with numerous programs and interventions to combat undernutrition and high rates of stunting among children. In 2013 Guinea joined the Scaling Up Nutrition (SUN) movement, a combined effort between participating governments, the UN, business, researchers and donors to support policy-level commitments to combat malnutrition during the critical 1,000 days window (SUN, 2014). The National Council on Food and Nutrition Security (CONSEA) is a multi-sectorial group, chaired by the prime minister's advisor on food and nutrition security and including the Ministries for Health, Agriculture, Social Affairs, Communication and the Environment (SUN, 2014). The government has also created the Food and Nutrition Division, based in the Ministry of Health and Public Hygiene, to coordinate the management of acute malnutrition activities. These activities include efforts like flour and oil fortification, vitamin A capsule distribution and salt iodization. Currently there are very few efforts being undertaken to improve or

stabilize the food supply. Nutrient-dense foods like fruits and vegetables are still relatively expensive and often hard to come by or just out of reach of the most nutritionally vulnerable households (table 21).

Table 21. Nutrition snapshot
Source: (SUN, 2014) unless otherwise noted

Malnutrition, under 5 years of age	
Wasting, under 5 years of age (WxH)	5.6%
Stunting, under 5 years of age (HxA)	35.8%
Underweight, under 5 years of age (WxA)* *source: (DHS, 2012) a decrease from 26.3% in 2005	18%
Minimum diets, 6-23 months of age	
6-23 months with Minimum Acceptable Diet	3.7%
6-23 months with Minimum Diet Diversity	7.6 %
Specific micronutrient deficiencies, under 5 years of age	
Anemia in children under 5 years of age	79%
Vitamin A deficiency in children under 5 years of age	48%

Two-thirds of infants are not fed an appropriate diversity of foods during the weaning stages (complementary feeding), which means that as children older than 6 months transition to solid foods, more than 60 percent of them are not getting a proper mix of nutritious micronutrient- and calorie-dense foods. Only 7.6 percent of children 6-23 months are meeting minimum dietary diversity of four or more food groups consumed each day. There are two main reasons for this. First, nutrient-dense foods are not available or affordable to parents; and second, there is not enough knowledge about proper feeding during the critical time between 6 and 23 months of age. Meeting children's dietary needs at this critical stage in child development is key to reducing overall rates of childhood stunting.

The World Bank has recommended five key actions to address malnutrition in Guinea; among those is improving dietary diversity through home production of a diverse of foods.

POSTHARVEST OF HORTICULTURE IN GUINEA AND THE SURROUNDING REGION

There is a lack of information on postharvest handling and storage of horticultural produce in Guinea beyond the survey that the Horticulture Innovation Lab conducted with smallholders. Therefore, this discussion of postharvest practices relies on information from the surrounding region and other developing regions.

The horticultural sector of sub-Saharan Africa has experienced marked gains in production over the past two decades. Bolstered by a concentrated effort to raise yields and soil fertility, horticulture in sub-Saharan Africa has started to play a role in a rapidly globalized and modernized food system (Megenthaler et al., 2009). In tandem with yields in high-value horticultural crops, the global food trade has climbed as well, placing increasing importance on fresh produce, dairy, and meat products (Akram-Lodhi, 2008). Yet this combination has not come without challenges for smallholder farming communities in developing countries. Increased value on the global market for horticultural crops has led to increased investment (both domestic and foreign) in food processing and retail. This flow of resources has found itself concentrated in large food processing companies, leaving those in farming communities without a means to efficiently access global markets (McCullough et al., 2008). Thus, attention has recently been turned to community solutions for boosting supply and demand at local horticultural markets. In order to accomplish these aims, researchers, investors, development practitioners, and governments have begun to focus more on postharvest storage and processing of high-value, perishable goods (Weinberger & Lumpkin, 2007). The following examples aim to illustrate a variety of efforts from researchers and community leaders to increase the value of their horticultural goods in order to reach quality standards for larger markets or to gain a higher premium in local markets.

RECENTLY TESTED POSTHARVEST STRATEGIES

A recent initiative at the Amity International Center for Postharvest Technology and Cold Chain Management in India with the World Food Logistics Organization assessed a wide variety of postharvest solutions for high-value crops in the developing world. In all, 10 interventions were seen as successes in garnering greater returns on investment for the smallholder farmer:

- **Liners for rough packages for transporting guava in India:** While reusable and recyclable, the plastic liners reduced damaged fruit and brought profits 5.5 times the cost of capital investment.
- **Smaller shipping packages for cabbage in Ghana:** Small sacks were shown to be profitable in the short-run and long-run, by reducing breakage. Per each ton delivered in small sacks, profits increased by $83 USD.
- **Wrapping of cauliflower heads in India:** Producers were able to sell wrapped cauliflower heads for twice the price of unwrapped heads, greatly increasing profits.
- **Field packing under thatched roof structure with concrete floor in Rwanda:** With a cleaner, dryer, and shadier place to pack produce for market, it was estimated that each metric ton of tomatoes brought in an additional $198 USD.
- **Shade shelters for spinach in India:** Using shade for packing and sorting leafy vegetables reduces evaporation and water loss, increasing available product weight for sale and maintaining quality. In India, these shelters were paid off after 18 uses.
- **Small zero-energy cool chamber in India:** A simple structure that is kept wet, built of clay brick and sand, was found to require only three uses to pay off the capital costs of the structure. Each load of 100 kg was able to yield an additional $40.50 USD.
- **Large zero-energy cool chamber in India:** Similar in composition to the small chamber, eight uses paid off the capital costs, and each metric ton load increased profit by $140 USD.
- **Small zero-energy cool chamber in Ghana:** Unlike in India, where three uses were able to pay off the initial investment, this chamber required 18 uses. However, each 200 kg load brought $58 USD in profit.
- **CoolBot onion room in Ghana:** The unit proved immediately profitable. High-value cool onions stored in the room yielded returns of $10,820 USD, as opposed to $2,100 USD for onions sold immediately after harvest.
- **Low-cost tomato processing in India:** While yields of tomato puree were low, the endeavor proved profitable immediately. It should be noted that processing in a rural setting would most likely require the purchase of materials not necessarily readily available. (Saran et al., 2010)

The projects above illustrate the vast and diverse postharvest potential for high-value, highly perishable crops in sub-Saharan Africa and elsewhere. While these are indeed profitable strategies, the largest setback is the initial investment. Risk-ambiguous farmers in sub-Saharan Africa frequently lack the capital to invest in a postharvest strategy, or are unwilling to, accepting the risk of losses over the potential for greater losses in trying a new technology. While credit and savings have made inroads in East Africa, West Africa still struggles with infrastructure and available credit to fund these operations.

POSTHARVEST CONSIDERATIONS IN GUINEA

While interventions and community projects are under way across East and Southern Africa, West Africa remains a difficult case. Whereas infrastructure exists in countries like Kenya, Tanzania, and South Africa for fortifying the supply chain and accessing potential technologies, countries like Guinea are not as fortunate. For instance, the government of Kenya recently embarked on an improved banana project aimed at rural cultivators. In addition to resources for the cultivation of bananas, a support network was elucidated between the Kenya Agricultural and Livestock Research Organization, Technoserve, the Ministry of Agriculture, the Kenya Industrial Research and Development Institute, the Banana Growers Association of Kenya, and the Horticultural Crops Development Authority. These entities aim to streamline the banana process through wholesalers (FAO, 2014). Smallholders in Guinea do not have access to such a robust supply and management chain.

POLICIES THAT IMPACT THE HORTICULTURE SECTOR IN GUINEA

In 2011, the government of Guinea launched a four year plan aimed at supporting agricultural investment and food security. This plan, divided into programs and goals, has three components related to horticulture: (1) food diversification and nutrition improvement, (2) promotion of agricultural exports and agribusiness development, and (3) improvement of agricultural services and support to farming organizations. Additionally in 2014, the government of Guinea worked with FAO to develop a national horticultural development plan to be implemented in five years. Both of these plans emphasize the need to promote horticulture for both food security and livelihoods improvement across the country. The government of Guinea has been providing seeds and fertilizers to farmer organizations at affordable prices. However, these seeds and fertilizers are not tested for quality or provided along with technical assistance, as noted above. As an addendum to the government's agricultural plans, the FAO outlined support of agriculture in its Ebola response plan in October 2014. This emergency initiative of the FAO provided technical assistance around Kissidougou where farmers were given seeds, fertilizers and training to restore their agricultural production systems.

EBOLA IMPACTS ON AGRICULTURAL PRODUCTION

While the West African Ebola outbreak has not been a major focus of this horticultural rapid assessment, it cannot be ignored completely. The epidemic has had direct and indirect effects on families and agricultural labor. Quantitatively the direct impact, in terms of number of infected persons in relation to the size of the population of the region, is very low. Most of the observed impact is due to border closures, restricted movement of people through the country and to neighboring countries, an exodus of people from infected areas, an increased reluctance to work in teams, and the collapse of the traditional work-sharing system.

Ebola started to spread during crop planting, before progressing rapidly during the harvest period of staple crops. Crops were impacted by a reduction of agricultural labor, which affected land preparation, weeding, chemical application, crop maintenance, and harvesting. In areas with Ebola, agricultural production declined as a result of reduced labor.

Many markets have been seriously impacted by the disruption of the flow of goods. The prices of rice, vegetables and livestock products recorded sharp drops in Ebola-affected production areas. The use of survival strategies is increasing in the most affected areas, especially in Forest Guinea. The food security of households that depend on agricultural wage labor, small trade, hunting and selling game products deteriorated sharply in most affected areas.

Overall domestic production of rice has decreased by 3.7 percent between the 2012-13 and 2013-14 agricultural seasons. That is about 77,000 tons of loss in absolute value. This relatively low impact of the disease at the national level hides greater effects on production and food security at the sub-national level. For example, the negative impact on rice production could be in the order of 8.5 percent in the N'Zérékoré region. Impact on the maize harvest is expected to be similar to that of rice, both at national and sub-national levels. However, cassava production is expected to be more resilient, with an average decline of about 1.2 percent nationally, ranging from 0 percent to 3 percent in the Labé and the N'Zérékoré regions.

The Ebola outbreak had repercussions on the production of export crops. Coffee and cocoa beans represent a significant share of exports from Guinea. The decline in production of these crops has also reduced household income resulting in a decline in purchasing power, which has restricted household access to food. Because of Ebola, many borders were closed, and severe restrictions were imposed on the international movement of goods. These factors have led to a decrease in trade flows and caused increases in transport costs. For example, Guinea exported significant quantities of palm oil, potatoes, fruit and coffee to Senegal. The closure of the border between the two countries had a significant impact on exports, prices and producers' incomes. The depreciation of the exchange rate is unlikely to lead to a rise in exports, but could instead reduce the purchasing power of households.

NATIONAL LEVEL AGRICULTURAL POLICIES

In 2007, the government of Guinean adopted a National Agricultural Development Policy – Vision 2015 (NADP) focused on the development of the agricultural and livestock sectors. The goal of NADP was to improve working conditions for

farmers and increase women's income while empowering farmer organizations. In addition to NADP, the government of Guinea has a National Food Security Strategy (SNSA). This strategy is focused on improving water management and storage.

A key aspect of the NADP was improving the agricultural export sector. During this time, Guinea exported potato, mango, orange, pineapple, banana, chili pepper, locust bean seed, and cassava to the neighboring countries of Mali, Senegal, Guinea Bissau, Cote d'Ivoire, Sierra Lone, and Liberia. NADP provided guidelines for trade that reduced inefficiencies and barriers to trade. For regional markets, the NADP aimed to grow the production of products such as pineapple, mango, banana, "little Guinea pepper," onion, shea butter, groundnut, palm oil, and yam. For the international market, the NADP focused on improving quality to meet standards for international trade of mango, pineapple, green bean, cherry tomato, melon, watermelon, strawberry, litchi, and cut flowers. Special attention was given to the development of urban and peri-urban horticulture and other income-generating activities that bring substantial revenue to women (salt production, saponification, dyeing, and postharvest processing).

Unfortunately, the progress of NADP was hindered by political instability. Between 2009 and 2013, Guinea experienced low growth, increased inflation, and a doubling of the national deficit. The current government has abandoned NADP, but still aims to implement agricultural and health policy changes. The new National Agricultural Investment and Food Security Plan (PNIASA) provides a roadmap for current government strategy and gives priority to rice as a crop that reduces poverty.

National policies fall in an environment characterized by several regional and international mechanisms such as the Economic Community of West African States (ECOWAS) Common External Tariff, Economic Partnership Agreements, and the World Trade Organization, which have significantly driven strategic thinking on the development of the agricultural sector over the last three years. The adoption of the Comprehensive Program for the Development of African Agriculture (CAADP) in Maputo in 2003 under NEPAD has given additional impetus to agricultural development. The extent to which Guinea can integrate into the greater ECOWAS agricultural zone will ensure agricultural improvement. Integration is an additional market opportunity for Guinean products including fonio, fruits and vegetables, cassava, peanut, grains, potato, cola, palm oil, banana, sweet plantain, and coffee, as there are over 250 million consumers in the ECOWAS zone.

INTERNATIONAL AND NATIONAL POLICY SUPPORT PROGRAMS IN GUINEA

The World Bank's Guinea Agricultural Support Project: The Agriculture Sector Support Project for Guinea is intended to strengthen the capacity of institutions and support the effective implementation of the PNIASA. The three components of this initiative are: (1) to build the capacity of the agricultural ministries in order to create a transparent and highly functioning institute, (2) provide analytical support to PNIASA implementation, and (3) support project management and implementation at the national level.

National Programme to Support Agricultural Value Chain Actors (PNAAFA): The PNAAFA is an International Fund for Agricultural Development (IFAD) program focused on building capacity of farmers organizations and developing a limited number of agricultural sectors with high economic potential for smallholders. It is part of the NADP, with farmers organizations as the main target beneficiaries. The overall objective of PNAAFA is to sustainably improve incomes and food security of the rural poor in Guinea.

WFP 1,000 days initiative: In 2014, the WFP and the Guinean Ministry of Health and Public Hygiene launched a chronic malnutrition prevention pilot project, funded by the Government of Japan. This project focuses on the period known as the first 1,000 days, which includes pre-pregnancy, pregnancy and care for children under 2 years old. This pilot project is extremely important as a basis to guide government actions in the fight against malnutrition. The region of Labé, where the pilot project is implemented, is one of the most affected by chronic malnutrition, with rates approaching a critical threshold of 40 percent.

This project addresses the three underlying causes of chronic malnutrition: inadequate dietary intake, inadequate feeding practices of infants and young children, and adverse health conditions. The project will last three years, target 3,000 pregnant and lactating women and 3,000 children aged 6 to 23 months in the localities of Tountouroun, Dionfo and Dalein in the Labé region.

The activities will consist of distributions of specialized nutritious food products (Plumpy'doz) to all children aged 6 to 23 months, whether or not they are affected by malnutrition. Similarly, 3,000 pregnant and lactating women will receive hygiene kits consisting of soap and chlorine for water bottles. In addition, the communication activities for the adoption of healthy and hygienic food behavior will be implemented for the targeted beneficiaries. This project, which is basically community-based, will allow better involvement of the population and promote durability and resilience of the community.

The project also aims to create a stronger connection between the population and health facilities by strengthening the capacity of health personnel. In addition, actions will be taken at the political and strategic level to strengthen government capacity to implement multi-sectoral programs that directly or indirectly prevent stunting. Project evaluations will uncover and disseminate best practices in food and nutrition nationwide.

United States government support of horticulture in Guinea: The USAID/Guinea mission has funded a number of projects strengthening small business and improving economic opportunities for farmers, women and youth. USAID's main projects are the Rural Microenterprise Development Guinea project, the Agriculture Education and Market Improvement Program, and the Sustainable and Thriving Environment for West African Development project.

Current projects include supporting human and institutional capacity development in agriculture and natural resources through partnerships with the ISAV and the U.S. Forest Service. Guinea is relatively new to democracy and in order to support the continued progress, USAID is supporting initiatives to strengthen governance, transparency, and mitigate conflict. Heath is an area of utmost importance to USAID in Guinea, and the agency has prioritized the strengthening of the Guinean health sector by improving health management systems, supply chain management and human capacity within the health sector.

CONCLUSIONS

The horticulture sector in Guinea, particularly in Southern Guinea in the livelihood zones studied, is thriving despite many challenges. This rapid assessment focused on the needs of farmers, traders and institutions. The recommendations that follow are an initial set of steps needed to strengthen the entire sector at this juncture.

Guinea has very favorable agro-ecological conditions for the production of horticultural crops including potato, onion, green beans, "little Guinea pepper," okra, pineapple, mango or citrus. However, while fruits and vegetables are grown throughout Guinea, production and access to fresh fruits and vegetables decreases as one moves further from the capitol of Conakry. It appears that rapid urbanization in Conakry will continue to play a key role in the consumption of fruits and vegetables. In addition to growing demand in Conakry, there is a strong level of demand for horticultural produce from neighboring countries and the international market. Efforts to bridge these gaps are important for increasing income and improving dietary diversity of farmers and consumers in Guinea.

In addition to distance to the markets in Conakry, many constraints and issues are prevalent in Guinean horticulture. There is little regulation over imported agricultural inputs (seeds, fertilizers and pesticides) in Guinea. This puts the safety of producers and consumers at a high risk. Additionally, farmers surveyed repeatedly told us that they would find seeds or agricultural chemicals that worked well only to not be able to buy those same inputs the next year in the market. The demand for inputs is higher than what suppliers can provide, and technical assistance and regulation on inputs is lacking.

In general, cropping systems are divided along gender lines where men farmers are responsible for grain production and women contribute to this grain production while independently growing cash crops to meet household expenditures. However, fruit and vegetable production practices are strongest in villages where both men and women are engaged in both activities. For women who are the sole producer of fruits and vegetables, this produce is a very important source of revenue, but they are less likely to use the improved production practices that men do. They use income from horticultural products to purchase food, pay for healthcare, purchase inputs and equipment, and pay for school. This income is so important to the poorest families that convincing them to eat their harvest to improve their dietary diversity may not make them any better off. Instead attention should be paid to not only increasing production, but also to ensuring that produce is conserved through proper postharvest and processing practices and that the nutritional value of adopting these practices are understood. A farmer will consume large quantities of her produce when she is able to dry and store that produce. Increasing fruit tree production addresses the two major production constraints (labor and inputs) while increasing rural nutrition levels.

Labor is a constraint in horticultural production. In fact, when surveyed, farmers and village leaders identified wealthier farmers by the amount of labor they had access to. Another constraint is lack of inputs and equipment. Given the limited quantity of labor, agricultural equipment and inputs at their disposal, smallholder farmers must make strategic decisions to maximize their pay-off in achieving food security first and financial security second. The poorest farmers have very limited power in the horticulture sector. These farmers sell their reserved grain when emergencies arise, even if they will have to purchase this grain back at a later time and at higher prices to eat. The poorest farmers have the least access to inputs, irrigation and implements. They make trade-offs that decrease their production potential such as selling their labor to work in their neighbors' fields when they could be using that labor to produce their own fruits and vegetables.

When farmers do have large harvests, they face a challenge in getting their produce to market. Many are resourceful and rent vehicles for the long trip to a major market, but a substantial amount of the harvest is lost, given away or sold at a reduced price. Production standards are often not met, limiting the Guinean farmer from being able to access export markets. This is particularly important for the few crops that Guinea is known for such as the "little Guinea pepper," mango and pineapple. Increasing farmers' abilities to meet market standards would open up new markets in crops such as citrus.

Farmers and traders repeatedly mentioned aspects of postharvest handling as a constraint to marketing their produce or getting it to market. There is a lack of processing and drying facilities, as well as a lack of knowledge about packaging materials that allow produce to withstand long trips across bumpy roads. Transportation is also a major limitation. The roads in Guinea are highly degraded and most goods are transported in inappropriate containers on old trucks or buses. After making the long trip to a major market, Guinean farmers are forced to accept low prices because they lack marketing and pricing information.

As with many pests in developing countries, the pests of Guinean horticulture are understudied. Many of the pesticides used by Guinea farmers have been discontinued in other countries because of safety reasons (Schroeder & Soumah, 2005). Farmers have not been trained on the safe and proper use of pesticides or on the concepts embedded in integrated pest management such as rotation of chemical modes of action or the protection of beneficial organisms.

In addition to lack of training in inputs and integrated pest management, there is a lack of institutional capacity in horticulture, in general. There are few agricultural researchers focused on horticulture, and institutions are located far from the areas in Guinea that could benefit from this research. However, there is great strength and trust in farmer and marketer groups (*groupements* and *unions*). These groups could provide the backbone to build human and institutional capacity.

Finally, the Ebola outbreak has impacted export of horticultural goods either because borders were closed or because Guinean products were not trusted. Ebola killed farmers and also made people wary of visitors. While not a constant constraint in Guinean horticulture, the impact of this latest Ebola crisis on farming must be considered in short-term development projects.

RECOMMENDATIONS

To conclude this assessment the Horticulture Innovation Lab, in consultation with horticulture experts from Guinea and West Africa, has put together these key recommendations. These recommendations are based on our own primary research in Guinea and supported by an in-depth literature review on the subject. Some recommendations are quite broad, while others are very specific. In some cases a specific solution is known and proven and makes solving the issue relatively straightforward, while in other cases further information would need to be gathered, potentially at the community level, to understand how an intervention might be received. In prioritizing our recommendations, we sought to move beyond an "everything is broken and needs fixing" approach to identify short-term recommendations that can also provide smallholders with long-term resiliency.

First we present recommendations in the horticulture sector, followed by specific recommendations for women and for farmers from different wealth classes. We wrap up our recommendations by suggesting approaches for individual and institutional capacity development and discussing interventions that are specific to each Livelihood Zone included in the assessment. The projects and strategies listed below each recommendation are examples of successful strategies observed in other countries. Those highlighted strategies are not meant to be prescriptive, but rather indicative of what can be done under each recommendation area.

Key recommendation: A horticulture sector strategy that intentionally prioritizes rural revitalization, one that empowers individual communities to take control over their livelihoods and create their own opportunities for agricultural investment and growth, is a strategy that would find support and success in rural Guinea.

OPPORTUNITIES THROUGHOUT THE HORTICULTURE SECTOR

For all wealth groups, the greatest limitations to selling more fruits and vegetables were quite similar. In order of importance, for most groups, these limitations were access to fertilizer, pesticides, dry-season irrigation, agricultural training, better postharvest handling options and transportation. Generally, access to credit was not a frequently reported limitation; however, facilitating access to credit for groups or individuals could greatly increase their ability to purchase inputs and basic technologies to improve production, yield and shelf life of perishable fruits and vegetables. The recommendations below encompass the entire horticulture sector from inputs to postharvest and from markets to nutrition.

INPUTS

We recommend that donors initiate and support access to horticultural inputs. Many farmers indicated that access to inputs was not consistent and our report outlined other problems such as a lack of technical assistance and inadequate testing of seeds. To counter this, we recommend that projects **facilitate access to loans or small grants and support seed production (research- or field-level) and seed banking techniques**.

An indicative initiative: The Feed the Future Ghana Agriculture Technology Transfer project has a unique model involving actors from the seed and fertilizer sectors, among others. The seed component seeks to develop public-private partnerships to facilitate demand-driven breeding, multiplication, certification and dissemination, as well as providing technical

assistance and support to local seed companies, industry associations, agro-dealers and related networks. A consultation with USAID/Ghana could reveal if this or a version of this would be an appropriate strategy.

An indicative initiative: The International Fertilizer Development Center (IFDC) and the World Bank have also used a markets-first approach, establishing a private-sector inputs market that focuses on affordability and quality. These projects are working in Nigeria, Ghana, Kyrgyzstan and other countries.

PRODUCTION

We recommend that donors promote improved horticultural productivity throughout the livelihood zones by **promoting simplified and sustainable farming techniques** (organic farming, composting, mulching, inter-cropping, crop rotation, etc.) that increase crop diversification and increase yields. Second, **promoting conservation agriculture practices in horticulture** would result in better adaptation to changing climate. Finally, many growers complained that roaming livestock damage their gardens and reduce their likelihood of planting again so the **promotion of basic fencing and animal husbandry practices** would help keep gardens for household and local consumption.

CROPS

Our assessment identified several value chains that have great economic and nutritional potential in Guinea. These are outlined below.

- **Chili pepper** is one of the most profitable and widely grown vegetables in Guinea. The main domestic markets for the product are in Conakry, Kindia, Labé, Kankan and N'Zérékoré. The two most common varieties are the Sikouly, a large fruited variety and the smaller "little Guinea pepper." The "little Guinea pepper" can produce as often as 10 times per year for up to three years. This smaller chili pepper has fewer pest issues and is spicier, which makes it more attractive to consumers. While they are known for this pepper, Guinean farmers are being out-marketed by farmers in neighboring countries. **Supporting this crop is recommended** and could be done successfully though a **seed marketing initiative, training in good agricultural practices (GAPs)** to meet export requirements, **building linkages between growers and international markets**, and **improving the processing of the chili** using modern low-cost technologies such as the UC Davis chimney dryer and grinders. Development of a GAPs manual through extensive research similar to the one developed by Horticulture Innovation Lab researchers in Nigeria on tomato in 2012 (discussed below) would be an ideal way to ensure that export markets can be accessible to chili pepper growers.

- **Okra**, like chili pepper, is very commonly grown and consumed both dried and fresh. In order to capitalize on current behavior, traditions and preferences, we suggest **increasing the support of production and drying of okra**. The UC Davis chimney dryer is a low-cost, highly efficient solar dryer that could be used to preserve okra at the household level. The dryer can also be modified for local materials and re-sized to accommodate small-scale commercial scale drying.

- **Eggplant** was ranked by growers as the single most important crop. For women this crop was particularly important. Profits in the dry season are around $35 USD per grower and up to $55 USD in the wet season. Growers suggested that **improving irrigation for dry-season production**, as well as **improving the quality and availability of fertilizers** in local markets. The World Vegetable Center (AVRDC) has been developing best practices, field guides, an integrated pest management manual and postharvest manuals specifically for eggplant. Continued support of this **research with specific recommendations** for eggplant in Guinea is important. As a globally important crop for both trade and nutrition, improving eggplant production in Guinea could result in much more economic stability for rural households. Given this crop's importance to women, improvements could have the added benefit of empowering rural women.

- **Tomato** is one of the most important crops in these Livelihood Zones. Tomato is grown for home consumption and sale and is typically not processed before sale. The West African Agricultural Productivity Program (WAAPP) has been successfully introducing newer pest-resistant tomatoes. AVRDC has also developed several tomato varieties suitable for different consumer preferences that can be tested in Guinea. With support for **research and testing of new varieties and pest management strategies**, Guinea could see improvements across the board in tomato production. The Horticulture Innovation Lab funded research in Nigeria (Enhancing Trade in Horticultural Crops through Food Safety

and Phytosanitary Measures) to develop a science-based GAPs curriculum and training program to improve production, food safety and phytosanitary compliance. **Developing the institutional capacity to design and implement GAPs** would increase tomato production, quality and safety while laying the foundation for expanded tomato exports and trade. This will increase the incomes of smallholder farmers, including women, and contribute to enhanced food security and economic growth. Currently growers must sell upwards of 90 percent of their tomatoes immediately after harvest because there is no postharvest infrastructure and poor transportation infrastructure, leading to high losses. Recommended **postharvest interventions** are shaded field packing, use of plastic crates and low-cost tomato processing into puree. These postharvest interventions have all proved profitable in other West African countries and in India.

- **Mangoes** in Guinea are highly productive trees. Farmers surveyed eat most of the harvest that doesn't rot on the tree (60%), and the fruits mature at the beginning of the lean season, when household incomes and nutrition plummet among the poor. **Fruit flies are the main pest.** If controlled properly during pre-harvest, 100 percent control of fruit flies can be reached. A combination of male annihilation technique (MAT) using methyl eugenol as a lure and improved sanitation has worked in India to bring down infestation levels from 60 percent to 5 percent, while the additional applications of decamethrin and azadirachitn can be used to reduce infestation to near 0 (www.infonet-biovision.org). In Kenya, the breeding of two species of parasitic wasps has been showing promise in reducing fruit fly presence in mango plantations. Hot water treatments would also greatly reduce postharvest losses. **Newer varieties** that ripen at different times of the year could extend the mango season for farmers. **Improvement in postharvest handling and storage** would also extend the season slightly. **Processing** mangoes into dried leathers or juices would open up additional revenue streams and create jobs in rural areas.
- **Oranges,** while commonly grown and always sold (over 90%), suffer high pest and disease damage. Growers interviewed stated that they commonly lose 50 percent of their oranges to disease and fruit flies right on the tree. Because oranges sell so well at market, any improvement would have immediate financial benefits to growers. **Investments in orange pest research** would pay off quickly.

PEST MANAGEMENT

In addition to crop-specific pest management recommendations outlined above, extensionists surveyed in our assessment expressed interest in **receiving manuals to help them identify pests**. Further research that we conducted also highlighted that farmers do not understand the principles of integrated pest management. Greater **training in the five components of integrated pest management** (pest identification, pest monitoring, development of specific pest management guidelines, pest prevention, and the use of a combination of biological, cultural, physical, and chemical tools) would dramatically improve the effectiveness of extensionists, provide research funding for researchers, and provide farmers with long-term pest management solutions beyond the short-term solutions suggested above.

CREDIT

Farmers in Guinea face challenges in accessing credit to purchase inputs, technologies or to start small agri-businesses. Microfinance institutions do exist throughout Guinea. While the microfinance sector in Guinea has been growing, these efforts have largely been centered on the urban and peri-urban areas of Conakry.

An indicative initiative: USAID supports a loan guarantee program through Development Credit Authority to enhance economic activities. The initiative leverages U.S. dollars in an effort to improve and expand Guinean small and medium enterprises through a local commercial bank. Greater **partnerships with local banks and with bankers who understand horticulture** could greatly improve growers' ability to access credit for needed investment and growth in the sector. In Guatemala, a U.S. Department of Agriculture, Foreign Agricultural Service-funded program with Counterpart International increased smallholder access to loans by teaching loan officers and bankers about agriculture. This education greatly increased bankers' and loan officers' understanding of acceptable risk in agriculture, and they increased agricultural loans as a result of their enhanced comfort with farmers' issues.

Savings groups in rural communities can empower women and provide them with access to needed capital. Savings groups can be one of the most effective, low-cost instruments to provide basic financial services to the poor, particularly in rural

areas, at very large scale. Guineans already work well in these types of groups, and rural communities in Guinea are quite organized. **Supporting savings groups** would be an opportunity to tap into pre-existing, well-structured groups. In Mali, Freedom from Hunger and Oxfam have shown that when savings groups are well run and organized, they can have great impact by increasing savings and ultimately, improving food security. Evidence from a randomized control trial done by Innovations for Poverty Action (IPA) and the University of Arizona's Bureau of Applied Research in Anthropology (BARA) also shows very positive results can be achieved by strengthening savings groups.

ENTREPRENEURSHIP AND MARKETING

We recommend that donors **promote the standardization and marketing of horticultural products** by supporting certification, regulation and normalization throughout the horticulture sector. Marketing should be facilitated throughout Guinea so Guinean farmers can increase exports to neighboring countries. **Technical exchange should be developed and reinforced** among all horticultural actors and practitioners including research, education, extension and producer organizations.

We recommend **training in basic agro-entrepreneurship skills and postharvest practices**. An initiative that supports basic organizational development and management would be welcome and beneficial. Basic feasibility studies should be developed that promote the involvement of producers in the horticulture sector. **Simplified postharvest technologies** (solar drying, processing, food preservation, etc.) should be promoted to strengthen the private sector as many of these technologies could serve as the foundations for small businesses.

Horticultural crops are high-value crops. Given the proper environment, even the poorest smallholders will invest in inputs and agricultural services to ensure a successful crop. As mentioned above, typical smallholder farmers inaccurately estimate the size of their fields, the number of their productive trees, the amount they spend on inputs, and their harvest size. Furthermore, productive trees in Guinea don't take up space in the same way they do in more developed agricultural systems. Some smallholders plant trees in rows with standard spacing, thus taking up a measurable space (even if they don't measure it), but just as frequently, productive trees are scattered throughout a certain section of forest that belongs to a given man farmer. **Training farmers to maintain better information** on the extent of their production, theirs costs and income could aid the farmers twofold: first, they would be better positioned to evaluate the benefits of investment, and second, this information could be shared with local agribusinesses, allowing them to better identify market opportunities and serve farmers' needs.

Donor programs need to systematically profile farmers throughout each intervention zone. The key to growing the agribusiness sector is meeting companies halfway by providing them the necessary market information of their potential clientele growers. **Small local agribusiness cannot afford to conduct market research**, but they will respond to opportunities when provided enough evidence of profitable services that can be sold to smallholders.

POSTHARVEST

Postharvest technologies would allow these farmers to control their harvest and increases their bargaining position in the markets. Empowering individual farmers and rural communities is the key to increasing rural food security and nutrition. Improved postharvest handing, processing and general education would go a long way in rural Guinea. Losses of harvested crops are extremely high across the board and, as we have shown in this report, any effort to reduce losses could increase sales and income for growers, traders and marketers. This can be achieved through **training in basic postharvest practices** such as using shade, reducing handling and damage, and using plastic bags or some type of improved containers for transport. Additionally, **setting up collection centers** that include places for washing, sorting and grading of produce and whenever feasible implementing cool storage solutions (such as a CoolBot-controlled cold room with solar panels) would decrease postharvest losses. **If smallholders could add mangoes, avocados, bananas, tomatoes or eggplants to the list of products they can conserve and process**, it is clear they would gain greater control over their sales, increase their bargaining power, and they would make more profit from their production. In villages where men perform at least 30 percent of the dry-season gardening, **farmers could benefit from postharvest training** and access to postharvest equipment.

POLICY

Integration into the greater ECOWAS zone offers Guinea potential for agricultural growth. With more than 250 million consumers in the ECOWAS zone, integration is an additional market opportunity for Guinean products including fonio, fruits and vegetables, cassava, peanut, grain, potato, cola, palm oil, banana, sweet plantain and coffee. **Any new investments in horticulture should have the support of local and national governments. By aligning new projects with current government priorities**, collaboration and success will be much easier to come by.

There is very little regulation of inputs, and this has a detrimental effect on the industry as a whole. Policy makers should consider **setting minimum standards for the importation and sale** of fertilizers, pesticides, seeds and other inputs. Currently, the application rate for fertilizer in much of Africa remains a small proportion of world average. It is vital that policies and investments support a competitive, private sector-led fertilizer and input industry in order to encourage a sustainable supply of much needed inputs. It is also important that this increase be implemented in an efficient and environmentally sound manner to avoid repeating mistakes of the Asian Green Revolution. Currently, IFDC is hosting meeting and conferences for policy makers on this topic, and we **recommend that Guinea's horticulture sector be represented at an upcoming meeting.**

NUTRITION

Malnutrition is one of the most important social, health and economic problems for this small, densely populated nation. Very few gains have been made over the last 10 years, and children within all sub-groups have relatively high levels of stunting (36%) and a lack of dietary diversity. As a member of the SUN movement, the government of Guinea is dedicated to making improvements and meeting nutrition-related policies and infrastructure goals. In order to make nutritional gains, as measured by specific indicators, a targeted approach must be taken. This would include a combination of interventions such as **household gardening along with nutrition counseling, education and behavior change communication**. We would also recommend that a **broader community-level approach to nutrition** be taken in any community where improvements to horticulture are being sought. This means that if there is a goal to improve production over a certain geographic area, effort should also be made to increase the consumer demand and consumption of the targeted crops. Public health campaigns, school-led education and creative marketing can all be used to improve local consumption of a variety of fruits and vegetables. AVRDC has promoted vegetable consumption with creative advertising in a number of countries. For example, in the Philippines they created an ad campaign similar to "Got Milk" ads of the 1990s, where local celebrities posed with vegetables.

RECOMMENDATIONS FOR WOMEN FARMERS

In addition to those recommendations highlighted above for women, there are several specific recommendations for women farmers that came from our research. Drying okra was much more common among women than the overall numbers of farmers who dry produce. The most commonly dried products were chili and okra. This presents an opportunity to **improve upon traditional drying methods** with the use of the UC Davis chimney dryer and some basic improved storage options.

Ultimately, our research has shown that when men are more involved in vegetable gardening, the women employ more sophisticated production practices, and when women own more trees, they control relatively stable sources of income and nutritious foods. Donor investments should **encourage the production of fruits and vegetables by men and women alike** because both genders bring unique skills and advantages to the two production systems. For example, in villages where men grow vegetables, women use more diverse pest management techniques, and men widely report that women are the ones who introduce new varieties to the village because they buy and sell vegetables in the local markets, where they are exposed to the advantages of new varieties.

RECOMMENDATIONS BY WEALTH QUARTILE

WEALTHIER

Overall, these growers have good production practices and are satisfied with the yields they are getting. It was this group across many regions that said that they **would prefer postharvest education or technologies over training related to production or inputs**. These growers are advanced enough in their production to begin to consider improvements to their postharvest challenges. These are growers who have the resources to move their product to nearby markets and those in Livelihood Zones GN02 and GN03 with access to the main markets in Conakry. **Conservation such as juicing, canning, pulping and even freezing**, if done at scale, could make for reliable markets for larger fruit growers.

MIDDLE

Farmers in this wealth group find themselves able to produce a variety of crops throughout the year; they have basic production knowledge and access to local markets. They don't have access to good inputs or as much training as they need. These growers also indicated a preference toward **postharvest skills and technologies over production training**.

POOR

For the two lowest income groups, a **more production-focused approach is recommended**. These farmers do not have a good understanding of basic horticultural practices such as plant spacing, integrated pest management or proper harvesting. These growers do not have enough of their staple grains to consume all year round (often only five months' worth is saved) and struggle to get through the lean months. These growers are extremely cash-poor and often they sell their labor rather than work their own land. Any **effort in the horticulture sector with these groups needs to consider how they are likely to allocate their time** and what possible adverse side-effects that may have on the success of an intervention. These groups could be greatly helped through **basic training on home gardens and nutrition**. Beyond the scope of this research, but still important, is the implementation of basic agronomic improvements necessary to help these growers produce enough of their staple grains to get them through the year, including the proper drying and storage of grains.

POOREST

Similar to the above group, this group struggles with a variety of compounding factors that make sustaining income and production difficult. **Training programs with a goal of improving basic production with an additional focus of providing some inputs** could greatly improve yields. **Home gardens** would again be a good introduction to horticulture and help families meet their daily nutritional needs before focusing on vast improvements to income. More than anything, these groups need **improved access to social safety nets** that would help them smooth over health- and environment-related shocks. Once savings aren't routinely drained to get through seasonal gaps or to help family members through illness, more time and money will be spent on productive activities such as horticulture.

HUMAN AND INSTITUTIONAL CAPACITY DEVELOPMENT

We recommend that a wholehearted effort be put into **developing the agricultural extension system** in Guinea. Regardless of how much effort is put into private sector development, without a supported and well-educated extension system, growers will have a difficult time advancing and solving problems on their own. Countries with well-funded extension systems have a much greater chance at sustainable growth in the agricultural sectors. This is not to say that a university- or state-led system is always the only way; there are creative solutions to providing training and resources to growers. Models such as the Farm Business Advisors from International Development Enterprises (iDE) have a place in a country's agricultural framework, but these private and donor efforts shouldn't replace a well-funded national extension system.

Of the 190 farmers surveyed, only 37 had contact with a state extension agent in the past year, but 78 percent of those reported that the extension agent provided useful information. The local extension agents, working for the *Direction Nationale d'Agriculture*, have a basic command of general agricultural practices, such as proper seeding and weeding techniques. However, they lack the necessary resources, technical information and accountability to effectively serve

growers. They are not provided with gas money to reach their constituent communities, they generally do not receive in depth training on improved practices or new techniques/varieties, and they are not held responsible for serving a given amount of farmers per month.

We recommend that an effort be made to **strengthen the national extension system** (*Direction Nationale d'Agriculture*). This can be done by training existing agents in improved practices and updated agronomic information. There is a great opportunity for donor investments to use these agents to support an effective, long-term extension system. By promoting access to (1) demonstration plots, (2) gas money, (3) agricultural training and (4) monitoring and evaluation of outreach and progress, donors can turn these agents into effective purveyors of agricultural research and knowledge. An inexpensive smartphone, phone credit and gas money could also help provide an agent with these necessities, without tying them to a fixed subset of villages.

As an example, extension agents in Mali are particularly enthusiastic about their on-farm demonstration plots, which allow them to show farmers the advantages of new varieties and practices; seeing is believing for risk-averse West African farmers. Several Guinean extension agents also expressed interest in acquiring a pest identification book, complete with pictures and recommendations, that could help guide their interaction with farmers.

RECOMMENDATIONS BY LIVELIHOOD ZONE

ZONE GN02 (PIEDMONT ZONE)

In the southern portion of the GN02 Livelihood Zone, banana, citrus, papaya and pineapple are important crops while mango, palm oil, okra, chili pepper, eggplant, cucumber and watermelon are grown throughout the zone. This is the largest horticultural producing zone in the country, and there is a lot of potential to support a wide variety of programs and see economic growth improve. We recommend that donors take a **value chain development approach that focuses on postharvest management, improved postharvest technologies, building market linkages and organizational development.**

ZONE GN03 (CENTRAL PLATEAU ZONE)

Much like GN02, GN03 has fertile soils and the ability to move products to large markets that are relatively close, either in Conakry or locally in Labé. Growers in the region are also able to access markets across the border in Sierra Leone. Producers in this zone would benefit from **improved postharvest handling and packaging** to better move their produce to markets and reduce loss. Given the importance of home and market gardens to household nutrition and income in this zone, improvements to production, small-scale food preservation, and nutrition would benefit these farmers.

ZONE GN09 (WOODED SAVANNAH ZONE)

Zone GN09 is a transitional zone between the forests of the south and the savannah. In Dabola and Faranah, we would recommend a **focus on diversification, introduction of improved varieties and cropping diversity**. This area has potential as a **hub of seed production**. This region could also be used as a source of sustainable economic growth and small business development. Additionally it would make a great impact to work with ISAV and with Winrock International in the region. In Kissidougou and Kerouane the main recommendations are to work on **crop diversification, technical training, support to organizational development, introduction of new and/or adapted crop varieties and facilitating commercialization.**

ZONE GN10 (PRE-FOREST ZONE)

In Livelihood Zone GN10, we recommend that donors initiate and **support crop diversification opportunities, small-scale irrigation** (to maintain horticulturists on fertile soils throughout the year), **provide training on seed production and conservation, and promote appropriate postharvest technologies and management.** Beyla is the area with the poorest horticultural production, thus these growers would benefit immensely from **basic training in production**. Given the presence of mining and other industries, employment opportunities off the farm are common, meaning that labor on-

farm is in short supply. **Labor-saving production methods**, such as plastic mulch to reduce weeding and drip irrigation to reduce watering, could go a long way. Those interviewed in this zone also reported higher earnings and assets, likely due to the diversification of employment opportunities. This means that there could be more potential here for investment into basic low-cost technologies to improve production, postharvest handling and storage. Drying okra was much more common in this zone than the others. This presents an opportunity to **improve upon traditional drying methods** with the use of the UC Davis chimney dryer and some basic improved storage options.

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APPENDIX A

FARMER AND FOCUS GROUP SURVEY

Numéro de la fiche: _____ Date: _____ l'enquêteur: _____

Village: _____ Prefecture: _____

Catégorie de richesse: ☐1 Pauvre ☐2 Intermédiaire

Household Profile (la famille nucléaire)

1. Nom du Répondant			
2. Sexe	☐1 Male ☐2 Female		
3. Age			
4. Origine Ethnique	☐1 Soussou ☐2 Peul ☐3 Maninka ☐4 Kisi ☐5 Baga ☐6 Kakabé ☐7 Toma ☐8 Kono ☐9 Kpelle ☐10 Lélé ☐11 Koranko ☐12 Other_____		
5. Nombre de membres du ménage		Homme	Femme
	Active		
	Inactive		
6. Niveau d'instruction	☐1. Aucun ☐2. Primaire ☐3. Secondaire ☐4. Ecole Coranique ☐5. Alphabétisation Fonctionnelle ☐6. Autres _____		

Household Consumption (Aucune = A, Une petite portion = PP, La moitié = M, La plupart = P, Tout = T)

7. Combien d'hectares cultivez-vous dans une année normale?	
9. Votre ménage cultive quelle partie de la céréale que vous (le ménage) mangez?	
10. Votre ménage achète quelle partie de la céréale que vous (le ménage) mangez?	
11. Votre ménage cultive quelle partie de les fruits et légumes que vous (le ménage) mangez?	
12. Votre ménage achète quelle partie de les fruits et légumes que vous (le ménage) mangez?	

Les actifs de ménage	**Quant**	**Prop**	**Quant**	**Prop**	**Quant**	**Prop**	**Quant**	**Prop**	**Quant**	**Prop**
13. Moto										
14. Vélo										
15. Télévision										
16. Radio										
17. Téléphone										
18. Panneau solaire										
19. Charrette										
20. Charrue										
21. L'âne										
22. Machine à coudre										
23. Les dépenses personnelle de thé et sucre hebdomadaires										

Systeme de Production Pendant l'hivernage

Champ	Hectares (M ou I)	Distance du village (km)	Engrais (GF)	Pesticide (GF)	récolte (# de 50kg sacs)	Quelles sont vos principales contraintes? Quels conseils techniques pourraient vous aider? (y compris la production, la gestion des ravageurs, post-récolte et la commercialisation)
Rice						
Corn						
Peanuts						
Corn						

Comment décidez-vous la quantité de superficie consacrer au production légumiere?	
Pourquoi vous ne consacrez pas d'avantage de superficie au production légumiere?	
Est-ce que tu cultive le hibiscus / autres légumes autour des champs comme de barriers?	

Systeme de Production Hors Saison

Speculation	Metre carré (M ou GC)	Quand seme-tu	Engrais (GF)	Pesticide (GF)	récolte (# de 50kg sacs)	Quelles sont vos principales contraintes? Quels conseils techniques pourraient vous aider? (y compris la production, la gestion des ravageurs, post-récolte et la commercialisation)

Cultures par ordre d'importance	Utilisation de la production	Qu'est-ce que vous achetez avec cet argent?

[1] 100% consommée [2] 75% consommée et 25% vendue [3] 50% consommée et 50% vendue [4] 25% consommée et 75% vendue [5] 100% vendue

24. Quelle est la profondeur de la nappe phréatique?	
25. Quels fruits, légumes, noix ou des champignons veux-tu cultiver (que tu ne cultive pas)?	
26. Porquoi?	
27. Pourquoi tu ne les cultive pas?	
28. Qu'est-ce qui t'empêche d'augmenter la production des fruits et legumes?	
29. Qu'est-ce qui t'empêche de consacrer plus de superficie à la production des fruits et legumes?	
30. Où es-tu autorisé à planter des arbres fruitiers?	
31. Qui a le droit de récolter des arbres fruitiers?	
32. Vous récoltez des fruits et des noix de laquelle les arbres?	
33. Quels sont les coûts de démarrage pour le jardin typique de ménage?	
34. Comment accede-tu à des intrants? Achete-tu en gros via des organizations paysanne?	
35. A quelles conditions le bétail mange les cultures légumières?	

36. De ta récolte légumières commercialisable, tu vende quelle partie?	☐1 Aucune ☐2 Une petite portion ☐3 La moitié ☐4 La plupart ☐5 Tout
37. Où est-ce que tu le vende?	
38. le point de vente est combien de kilomètres d'ici?	
39. Le consommateur paye combien pour eux?	
40. Connais-tu le prix avant que tu les récolte?	
41. Combien d'argent pouvez-vous gagner par mètre carré de jardinage? Quel est le legume dans ce mètre carré que vous pensez?	
42. Quels sont les changements qui arrivent au marché légumières?	
43. Quels sont les changements qui arrivent au marché de fruits	
44. Qu'est-ce qui t'empêche de vendre plus de fruits et légumes?	Question ouverte; il faut classer: __ capacité limitée pour transporter les produits vers les marchés __ l'accès limité à l'eau pendant la saison sèche __ limité connaissances de bonnes pratiques __ accès limité aux pesticides __ limitée la demande du marché __ accès limité à la terre clôturée __ Trop difficile de tirerde l'eau __ accès limité aux engrais __ Produits gâcher après la récolte __ bénéfices limités
45. Imaginez que le marché a une grande demande pour les tomates, et si tu cultive plus de tomates, vous étiez sûr de les vendre pour un profit. Comment tu augmenterais ta production?	
46. Es-tu une member d'un groupe de marketing, ou vende-tu tes légumes tout seul?	
47. Séche-tu tes legumes ou fruits? Comment? Quelles produits?	
48. tu tries tes legumes ou fruits? Quelles produits?	
49. À quel moment de la journée récolte-tu? (pour tous les speculations)	
50. Comment est-ce que tu nettoyes et entretiens ta produit récolté?	

51. Comment tu transporte des fruits et legumes au marché?	
52. Comment gardez-vous les produits frais après ils sont récoltés?	
53. Quelle partie de votre récolte est trop endommagée pour le vendre?	☐1 Aucune ☐2 Une petite portion ☐3 La moitié ☐4 La plupart ☐5 Tout
54. Quelles sont les pratiques post-récolte que tu veux adopter?	

55. Qui plante tes légumes?	
56. Qui enleve les mauvaises herbes de ta jardin?	
57. Qui arrose tes légumes?	
58. Qui vends les fruits et légumes?	
59. Qui contrôle le revenu de ces ventes? Fruits? Legumes?	
60. Est-il l'extension nutritionnel qui est axé sur les fruits et légumes?	

61. Comment est-ce que tu classes ces opportunités génératrices de revenus?	
62. Dans quelles saisons avez-vous le temps de cultiver des légumes?	☐1 saison froide ☐2 saison chaude ☐3 saison des pluies
63. Combien des heures par jour pouvez-vous consacrer au cultivation légumeire dans chaque saison?	___ saison froide ___ saison chaude ___ saison des pluies
64. Quelle est la différence entre ceux qui cultivent des légumes et ceux qui ne le font pas?	
65. La parcelle légumiere chez toi est de quelle taille? (Metre carré)	
66. Quelles sont les priorités financières qu'il faut satisfaire avant que tu peut manger d'avantage de légumes?	
67. Que faudrait-il pour vous de manger d'avantage de légumes?	
68. Si votre production a doublé, vendriez-vous toute votre récolte? Ou bien mangeriez-vous d'avantage des legumes?	

69. Comment accédez-vous à des	

semences non-certifiées?	
70. Comment accédez-vous à des semences certifiées?	
71. Quelle partie de vos semences légumieres sont non certifié?	☐1 Aucune ☐2 Une petite portion ☐3 La moitié ☐4 La plupart ☐5 Tout
72. Si vous aviez plus d'argent, vous achetez des semences certifiées, ou voulez-vous continuer à utiliser des semences locales? Est-ce que les semences certifiées sont plus rentable?	
73. Comment conservez-vous semence légumieres?	
74. Ta communauté a besoin de quoi pour améliorer leurs semences légumiere de base?	
75. Les semences de quelles speculations légumiere functionnent bien?	
76. Les semences de quelles speculations légumiere ne functionnent pas bien?	

	State Extension Agent	Private Input Dealer	NGO Project
Combien de fois avez-vous eu des contacts avec les agents de vulgarisation?			
Répondent-ils à vos besoins réels?			
Décrivez le dernier contact que vous aviez avec un agent de vulgarisation? (date, sujet, expérience)			

Etes-vous membre d'une organisation de jardinage ?	☐1 Oui ☐2 Non
Vous réunissez-vous à quelle frequence?	☐1 quotidien ☐2 hebdomadaire ☐3 Mensuels ☐4 6 fois par an ☐5 chaque année
Quels sont les avantages d'adhésion ?	☐1 L'accès au crédit ☐2 L'accès a l'épargne ☐3 Achats en gros des intrants ☐4 Vente collectives de céréales ☐5 L'aide avec votre production ☐6 L'accès a l'information ☐7 Camaraderie and le soutien social ☐8 Autre _____
De qui pouvez-vous emprunter de l'argent ?	☐1 Personne ☐2 Amis et famille ☐3 Les prêteurs privés dans la communauté ☐4 Banques ☐5 Commerces, entreprises ☐6 Coopératives communautaires d'épargne ☐7 Autres _____
à quelle taux?	
Etes-vous membre d'une organisation d'epargne? De quelle genre?	
Était-il commencé par un projet? Est-il encore soutenu par un projet?	
Souhaitez-vous appartenir à un groupe d'épargne et de crédit? Si oui, quel genre?	

Comment pouvez-vous dire si quelqu'un dans ce village est plus riche ou plus pauvre que le reste?	
Entre les riches et les pauvres, quelles sont les différences entre leurs pratiqués d'agricoles?	
Quels sont les aliments que les riches mangent pour lesquels les pauvres n'ont pas les moyens.	
Ou se trouve votre ménage par rapport à d'autres dans votre village?	☐1. Riche ☐2. Intermédiaire ☐3. Pauvre ☐4. Extrêmement pauvre

	Quant	**Prop**	**Quant**	**Prop**	**Quant**	**Prop**	**Quant**	**Prop**	**Quant**	**Prop**	**Quant**	**Prop**
bétail												
chèvres												
mouton												
Volaille												

MARKET QUESTIONNAIRE

Nom de l'Enquêteur: _____ Sous-Prefecture_____ Ville / Village _____ Date _____

1 Nom de marché	
2 Nom de commerçant grossiste	
3 Numéro de téléphone	
4 Sexe	1 Masculin 2 Féminin
5 Age	
6 Région d'origine	1 Basse Guinee 2 Moyenne Guinee 3 Haute Guinee 4 Guinee Forestiere
7 Quel est votre niveau d'instruction	1 Primaire 2 Niveau troisième 3 Niveau bac 4 Université sans diplôme supérieur 5 Licence 6 Autre à préciser_____ 7 Rien
8 Quells produits commercialisez vous?	1 acajou 2 ananas 3 aubergine 4 avocat 5 banan 6 bisap 7 cacao 8 carotte 9 café 10 concombre 11 citron 12 coco 13 guave 14 gombo 15 goyo 16 laitue 17 mangue 18 okra 19 oignon 20 orange 21 papaye 22 palmier 23 pastèque 24 patate 25 piment 26 pommes de terre 27 tomate

	Nom de Commune	Leurs Produits -- il faut utilizer les numerous en haut!	Partie de la Commune (plusiers reponses possibles) 1 l'ensemble de la Commune 2 la partie nord 3 la partie orientale 4 la partie sud 5 la partie ouest	Lieu d'approvisionnement 1 ici (producteurs viennent au marché) 2 Marché du petites villages 3 Bord champ 4 Autre a préciser
9 D'où viennent vos vendeurs? il faut utilizer les numerous				

10 Est ce qu'il vous arrive de vendre à crédit à vos clients ?	1 Très souvent 2 Quelques fois 3 Jamais
11 Si vous vendez à crédit quelles sont les échéances ?	1 Une semaine 2 Deux semaines 3 Un mois 4 Autre à préciser_____
12 Par contre est ce qu'il arrive que vos clients vous donnent des avances ?	1 Oui 2 Non
13 Est ce qu'il vous arrive de ne pas vendre tous vos produits ?	1 Très souvent 2 Quelques fois 3 Jamais
14 Que faites vous quand vous ne vendez pas tous vos produits ?	1 Je les ramène 2 je les détruis 3 Je les donne à crédit à mes clients 4 Autre à préciser _____
15 Quel genre de relation avez vous avec vos fournisseurs?	1 Strictement des relations d'affaire 2 De relations de famille 3 Des relations d'amitié 4 Autre à préciser_____
16 Est ce qu'il vous arrive de faire des avances de fonds à vos fournisseu	1 Très souvent 2 Quelque fois 3 Jamais
17 Si oui, à quel moment le faites vous ?	1 Pendant la période des cultures 2 Pendant la période de récolte 3 Pendant la periode des fêtes 4 Autre à préciser
18 Est ce qu'il arrive que votre fournisseur vous accorde certaines facilités ?	1 Oui 2 Non
19 Si oui lesquelles ?	1 Echéances de payement 2 Des compléments de marchandises en terme de cadeau 3 A nouer des relations avec d'autres fournisseurs 4 A résoudre certains problèmes de famille
20 Est ce qu'il vous arrive de faire des commissions en ville pour votre fournisseur ?	1 Oui 2 Non
21 Si oui de quel genre de commission s'agit il ?	1 Des achats des produits en ville 2 Transport de courrier ou de message en ville 3 Intervention dans l'administration en ville 4 Autre à préciser
22 Avez vous connu des périodes d'interruption dans votre activité ?	1 Oui 2 Non
23 Si oui, quelle a été la durée de cette interruption ?	_____ mois
24 Quelle était la cause de cette interruption d'activité ?	1 Maladie 2 Problème financier 3 Problème de famille 5 Autre à préciser_____

APPENDIX C

KEY STAKEHOLDERS IN GUINEAN HORTICULTURE

PRIVATE AGENCIES AND NGOS

- COPEFL (Coopérative des Producteurs et Exportateurs des Fruits et Légumes de Kindia)
- FABIK (Ferme Integree, Kondeyah, Kindia)
- COPRACAM (Coopérative des Producteurs)
- FUMA (Fédération des Unions Maraichères de Haute Guinée)
- FOPBG (Fédération des Organisations Paysannes de la Basse Guinée)
- Wakili de Tinkisso (Groupement Maraîcher a Dabola) et Conseillère Agricole Dabola
- AFTT (Association des Femmes Techniciennes et Technologues, Kankan)
- Union des Groupements Maraichers de Kindia
- RIEAG (Réseau des Institutions d'Enseignement Agronomique de Guinée, Winrock International, Faranah)
- Djouma Fleur, Sebhory, Dalaba
- APEK-Agriculture (Association pour la Promotion Economique de Kindia)
- ONG ATC (Assistance Technique et Coopération, Dabola et Kindia)
- APARFE (Association pour la Protection, l'Amélioration des Ressources Forestières et Enrichissement, Kissidougou)
- PACV (Programme d'Appui aux Communautés Villageoises, National, Aménagement et Construction d'infrastructures)
- Fasso Demeh, Groupement Maraicher, Kankan
- Union des Groupements Maraichers de Mamou
- ONG RAFOC (Réseau d'Appui Financier aux Organisations Communautaires, Région de Kankan)

GOVERNMENT AGENCIES

- ANPROCA (Agence Nationale pour la Promotion et le Conseil Agricole, Conakry avec démembrements a l'intérieur du pays)
- DNA (Direction Nationale de l'Agriculture, Conakry avec démembrements a l'intérieur du pays)
- DRA (Direction Régionale de l'Agriculture, chaque région administrative)
- DPA (Direction Préfectorale de l'Agriculture, chaque Préfecture du pays)
- Centre de Promotion de l'Horticulture, Dounkimagna, Sebhory, Dalaba (Moyenne Guinée)
- RADHORT (Rassemblement Africain pour le Développement de l'Horticulture), Direction Nationale de l'Agricutlure, Almamyah Conakry

UNIVERSITIES AND SCHOOLS

- ISAV-VGE de Faranah, ENAE de Bordo-Kankan, ENAE de Koba-Boffa, ENAE de Tolo-Mamou, etc
- Centres de Recherche Agricole (Kindia, Macenta, Kankan et Pita)
- Agence Nationale des Statistiques Agricoles (ANASA, Conakry)
- Direction Nationale pour la Sécurité Alimentaire (Ministère de l'Agriculture)

INDIVIDUALS

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Name	Position	Organization	Location
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Fanta Diane	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Faranah
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Filamoré Camara*	Farmer		Djakofomodu, Gbakédou
Floriane Thouillot*		GRET	Conakry
Fode Sylla*	Gerant	COPEFL	Kindia
Fofana Mohamed Lamine*		HKI	Conakry
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Ibrahima Barry	Directeur General Adjoint/ AEMIP	AEMIP Agriculture Education Market Improvement Program	Conakry

Name	Position	Organization	Location
Ibrahima Bah*	Charge de la Recherche	CRAK	Kindia
Ibrahima Barry*	Assistant Directeur	Winrock International	Faranah
Ibrahima Diallo	Country Director	Farmer to Farmer/Winrock	Conakry
Ibrahima Diallo Tanon	Agronome	IFAD-Intenational Fund for Agriculture Development	Conakry
Ibrahima Touré	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Télimélé
Inbrahima Sylla	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Dubréka
Ismael Diallo	Directeur National	OICI-G	Conakry
Javier Rodriguez		UNICEF	Conakry
Jean-Luc Faber*	Chef Division Strategie et Prospective	Ministère de l'Agriculture	Conakry
Kalifala Fofana*	Agroforestry Program Manager	Peace Corps Guinea	Conakry
Kegna Balde*	Directeur	Promotion Horticulture	Dalaba
Kerfalla Camara		MGE	Conakry
Koumba Keita*	Conseillere Agricole	ANPROCA	Dabola
Kowo Zoumanigui*	Selection Varietale	Promotion Horticulture	Dalaba
Krstic Anika		ACF	Conakry
Lansana Conde*	Conseiller Agricole	ANPROCA	Kankan
Laye Keita*		Direction Nationale d'agriculture	Conakry
Lola Wilhelm	Analyst	ACAPS- Assessment Capacities Project	Conakry
M Djouma Barry*	Planteur		Dalaba
Mady Sidibe*	Directeur	ANPROCA	Kankan
Malabo Kaba		PAM	Conakry
Mamadi Camara*	enseignant-chercheur	l'université GLC de Sonfonia-Conakry	Conakry
Mamadou*	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	
Mamadou Baldé*	Technical Lead	Union de Groupement Agricole	Soumbalako
Mamadou Cellou Diallo*	Conseiller Agricole	DPA	Maferinyah
Mamadou Ciré Baldé	DNAAHP	Ministere de l'elevage	Conakry
Mamadou Dian Diallo*	Animateur	PACV	Mamou
Mamadou Diane	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Mamou
Mamadou Issa Diallo*	President	Groupement	Maferinyah
Mamadou Malal Sow		RAJ-Gui	Conakry
Mamadou Soumah	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Pita
Mamadouba Conté	Directeur Commercial Elevage	Elevage Commune Matoto	Conakry
Mamady Kensa Conde*	Membre Groupement	Fasso Demeh	Kankan
Mamady Koulako Kouyate*	Charge des Programmes	FUMA	Kankan
Mamady Kourouma*	Recherche IRAG	IRAG	Conakry
Mamy Keita	Directeur Executif	ACA- Agence pour la Commercilisation Agricole	Conakry

Name	Position	Organization	Location
Maoussa Kane	Directeur General Adjoint	Societe de Production et commercial-ization des intrants agricoles-SPCIA	Conakry
Marcel Noramou*	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Gbakédou
Mario Tedo*		FAO	Conakry
Marlyatou Bah	M&E Coordinator	PRADD II- Droit de Proprete et De-veloppement du Diamant Artisanal	Conakry
Maxim T Kamano*	Directeur	CRRAF	Kindia
Mme Kamissoko	Directrice Programme OIC	OIC- Opportunite Industrialization Center	Conakry
Mme Mar Pozuelo	Expert food security	Action Contre la Faim	Conakry
Mohamed Conde*	Coordinateur	ATC Haute	Dabola
Momo Soumah*	DA Programmes	FAO	Conakry
Moriba Ramos Camara*		AGIR	Conakry
Morlaye Sylla*	President	Union Maraichers	Kindia
Mory Doumbouya		REGOSA (Engineering firm)	Conakry
Mouctar Balde*	Coordinateur	ONG ATC	Kindia
Moussa Camara	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Kindia
Moussa Kuroma*			Djakofomodu, Gbaké-dou
Moustapah Donzo	Responsible planification, S&E	Institut de la Recherche Agronomique de Guinee (IRAG)	Conakry
Mr Camara*	Directeur	ONG RAFOC	Kankan
Muhamady Kandey		PNUD	Conakry
Nadica Rinic	VAM Officer	World Food Programme	Conakry
Naman Camara		Terre des Hommes	Conakry
Nantenin Conde*	Presidente	Association AFTT	Kankan
Nathalie Konan*		Sécurité alimentaire MA	Conakry
Nene Ousmane Barry		MEPA/ DNAHP	Conakry
N'famba Kamano	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Dinguiraye
Nicolah*	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	
Nyanbele Maomy*	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Moussadou
Odia Sanoh		PAM	Conakry
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Pathe Diallo*	Correspondant Mais	CRAK	Kindia
René Ifono*		FAO	Conakry
Rosalia Gitau		OCHA	Conakry
Rosalie Haughton		CRS	Conakry
Saliou Cherif Diallo	Directeur General	Bureau de la Strategie et Developpe-ment	Conakry
Sayon Traore*	Formation, S&E	FUMA	Kankan
Seckou Doré		RAJ-Gui Reseau Afrique de Jeunesse	Conakry
Sekouna Camara*	Chef Centre de Recherche	CRAK	Kindia
Semmy Niakoi*	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Doubadou, Diarragréla

Name	Position	Organization	Location
Seny Mane	Directeur National Service veterinaire	Ministere de l'Elevage et de la Production animals	Conakry
Seydou Sako*	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Konsankoro
Siba Dopavogui*	Charge legumineuses	CRAK	Kindia
Siba Koivogui*	Directeur	DPA	Beyla
Sidafa Conde'	Directeur National Adj	Ministere de l'Agriculture	Conakry
Soua Zbélo*	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Moussadou
Souliman Guaye*			
Souret Diawara*	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Kissidougou
Tamba Camara	Dir. Préfectoral d'agriculture	Direction Nationale d'agriculture	Dabola
Thierno Hamidou Camara*	Charge Maraichage	CRRAF	Kindia
Traore Adama		MEPA/ Ministère de l'élevage	Conakry
Yackouba Condé	Dir. Regional d'agriculture	Direction Nationale d'agriculture	Faranah
Youla Djènahou		PLAN	Conakry
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RAPID ASSESSMENT OF
THE HORTICULTURE SECTOR IN GUINEA

This publication was produced for review by the United States Agency for International Development. It was prepared by the Horticulture Innovation Lab at the University of California, Davis.
http://horticulture.ucdavis.edu

Appendix 4 - Open data management plan

Data Management Plan

Feed the Future Innovation Lab for Collaborative Research on Horticulture
University of California, Davis

Submitted by Amanda Crump, associate director to John Bowman, AOR on August 31, 2015.
Approved on _____ by _____.
Modified on _____by _____.

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

Data collected by the management entity

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

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

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

Data collected by every project

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

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

Data collected by individual projects

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

Regional Center at Kasetsart

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

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

Regional Center at Zamorano

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

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

Irrigation technologies project in Uganda

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

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

Grafting of tomatoes project in Guatemala and Honduras

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

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

Nutrition research project in Zambia and Kenya

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

Institutional Review Board (IRB)

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

Elements of Data management plan

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

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

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

verification, data conversion and transformation, data uploading and storage and oversight, yet each of these tasks will be required to be borne by research group.

Dataset #2: Household AIV purchase and consumption

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

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

- Description: Agricultural yields under different production systems, and nutritional content/composition of AIVs.
- Data Privacy & Use Restrictions: None.
- Pre-submission data processing: Normal processing prior to publication
- Final Data Deliverable: Excel file
- Timeline: Dataset will be released upon publication and following QCed of data
- Data repository & post-award curation: USAID DDL
- Responsible Party: Rutgers University
- Target Submission Date: 2020
- Associated Costs: We are expecting > 20,000 analyses surveys that need to be QCed/verified, aggregated, analyzed merged for publications, clarity, stored, archived, initial cost estimates are at $10,000/year).

Gender equity research project in Honduras

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

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

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

- Description: Production of horticultural crops, women's empowerment and dietary diversity.
- Data Privacy & Use Restrictions: Restricted; adhering to IRB policies regarding confidentiality of human subjects
- Pre-submission data processing: Data will be cleaned, aggregated and all personal identifiers removed.
- Final Data Deliverable: SAS/Excel file with 300-350 observations
- Timeline: Collection and cleaning – 2016; analysis – 20167 publication – 2018-19; submission to USAID -- 2020
- Data repository & post-award curation: USAID DDL; Penn State University
- Responsible Party: Penn State University
- Target Submission Date: 2020
- Associated Costs: Est. additional costs at $10,000 for data aggregation, quality assurance (QA) and storage of data with costs associated with personnel assigned to provide oversight, back-up and convert data into sharing format as agreed upon that may not be how data are collected, checked, and stored by research group.

Conservation agriculture and drip irrigation project in Cambodia and Nepal

Cambodia:

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

- Description of data: Vegetable yield by each farmer we incentivized adoption of drip irrigation with conservation agriculture technologies, Production cost by each farmer, Income by each farmer
    - Ten farmers will be randomly sampled and we will monitor:
        - Water use by drip irrigation

        - Labor from drip
        - Labor from weeding
        - Labor from seeding
        - Labor from mulching
- Data Privacy & Use Restrictions: No names of farmers, we expect up to 100 participating farmers
- Pre-submission data processing: Data will be processed as is appropriate for publication
- Final Data Deliverable: Website from the iFarmCA App (http://www.conservationagricultureandagroforestry.org/ifarmca/index.php/search). Raw data (no quality control) accessible as it is being collected in field.
- Timeline: Upon publication, approximately 2018
- Data repository & post-award curation: Dataset will be uploaded to the USAID Development Data Library (DDL) after publication.
- Responsible Party: North Carolina A&T State University
- Target Submission Date: 2018
- Associated Costs: Negligible

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

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

Nepal:

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

- Results of experiment with 24 women commercial vegetable home gardeners, six in each site. Each farmer is a replication managing three treatments and they are:
    - Conventional Tillage System with Drip Irrigation
    - Conventional Tillage System with Integrated Pest Management Technology and Drip Irrigation
    - Conservation Agriculture System with Integrated Pest Management and Drip Irrigation
- Description of data for each treatment:
    - Vegetable yield by each farmer
    - Production cost by each farmer
    - Income by each farmer
    - Water use by drip irrigation

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

Appendix 5 - Monitoring and evaluation plan

Monitoring and Evaluation Plan – Feed the Future Innovation Lab for Collaborative Research on Horticulture

Updated October 2015

---Paul Marcotte, Amanda Crump, and Elyssa Lewis

Preamble

This Monitoring and Evaluation (M&E) Plan supersedes and builds off of previous work plans developed by Paul Marcotte and Amanda Crump. It has been adjusted to address the complexity of assessing Horticulture Innovation Lab projects. It is specific and pertains to the structure of Horticulture Innovation Lab for FY2015-FY2019.

Framework

There are four main components to this M&E Plan. We understand that monitoring and evaluation is made of these things:

- Project progress towards objectives
- Outputs – project activities, products, trainees, and other items that we count
- Outcomes – the direct changes we see in people or production systems as a result of our projects
- Impact – the changes that are beyond the outcomes or the things that have changed in the community or ecosystem as a result of our projects

Because of the difficult nature of monitoring and evaluation, it is easiest to monitor and evaluate outputs and most difficult to assess impact. This plan is all encompassing and seeks to analyze outputs, outcomes, and impact.

Methodology

The evaluation team is comprised of Paul Marcotte, Amanda Crump, and Elyssa Lewis. Paul provides an outside perspective on the Horticulture Innovation Lab, while Amanda is responsible for project management and provides an internal perspective. Elyssa is a graduate student with interest and expertise in monitoring and evaluation. This team has been trained in both natural and social sciences and are able to conduct both qualitative and quantitative assessments.

Assessing Project Progress

At the proposal stage, projects funded by the Horticulture Innovation Lab develop a log frame monitoring and evaluation plan based on their objectives. The projects address their objectives through defined activities which have specific outcomes and measures of success. We request that they critically think about how they will measure and document their success and how they envision the impact of their project. This M&E plan is then reviewed by Amanda and Elyssa, who give advice/feedback on how improve it, if necessary.

Annually, 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 project report. Annually, this report is assessed to ensure that projects are making timely progress.

At the mid-point of each project, the project leaders are contacted by Paul Marcotte to assess their satisfaction with their project and with the Horticulture Innovation Lab management team. Because Paul is outside the Horticulture Innovation Lab management team, he is able to suggest critical changes to our management system through his reports of this interaction.

At the end of a project, several M&E 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 will primarily be assessed utilizing Feed the Future agricultural indicators selected by the Bureau of Food Security at USAID. In addition, the Horticulture Innovation Lab has developed a set of indicators in capacity building. 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 management team, are allowed to revise their indicators on an annual basis.

Assessing outputs in this way is quantitative and gives the Horticulture Innovation Lab management team the ability to measure a number of different indicators quickly. While not indicating impact, these outputs do inform the management team 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 management team visits one of the Horticulture Innovation Lab projects in the field, they are asked to interview project team members. The interview questions for this activity are in the Horticulture Innovation Lab files. 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, our team measures outcomes from the report narratives that the project leaders write annually. These project narratives and on-the-ground reports help us understand what is happening to the people and the production systems in the projects. These outcomes also guide the management team as they decide which projects to scale up and where to invest in upcoming years.

Assessing Impact

Measuring impact is the most difficult of any M&E plan. Our approach is to visit the project sites at least one year after the end of the project. Our site visits determine the impact of the project's efforts in capacity building, developing collaborations, and technology implementation. These visits also allow us to understand how people beyond the reach of our project have been impacted and how the community or ecosystem beyond the direct reach of our project has changed.

At the beginning of the most recent Horticulture Innovation Lab projects, the project leaders were asked to implement a baseline survey. It is partially against these baseline surveys that we will measure our long-term impact and success.

Reports

The M&E team provides reports to the Horticulture Innovation Lab management team as needed. They also contribute to the annual reports and other reports needed by USAID. The information gathered through the M&E plan informs the communications team in their work to create awareness of Horticulture Innovation Lab impact. At the end of each final project visit (or the final assessment of the M&E team if they are unable to visit), a final report will be written on each project and presented to the management team in year 5 of the Horticulture Innovation Lab as the team builds their workplan and proposal for subsequent phases of Horticulture Innovation Lab.

Travel Priorities

FY13 – Assess Immediate Impact Projects and Exploratory Projects

Priority 1 projects to review:

- Barrett IIP – UC Davis DONE
- Bennett IIP – Honduras DONE
- Thompson/Reid IIP – Honduras, Uganda, and India (priority=Honduras and Uganda)
- Ristaino IIP – several Central American countries (priorities=Honduras and Guatemala) NO
- Santos IIP – several Central American countries (priority=Honduras) DONE
- Simon IIP – Ghana DONE
- Fennimore EP – Kenya NO
- Kleinhenz EP – Kenya NO
- Boellstorff EP – Malawi DONE
- Bates EP – Thailand DONE
- Paull EP – Vietnam and Cambodia (priority=Cambodia) DONE
- Coffman EP – Bangladesh DONE

Priority 2 projects to review (because these projects have become larger projects and can be assessed later or because of Feed the Future priorities):

- Bradford IIP – Nepal, India, and Thailand (priority=Nepal)
- Scow IIP – Uganda
- Nienhuis IIP – El Salvador, Honduras, and Nicaragua (priority=Honduras)
- Bonsi IIP – Ghana

- Simon IIP – Zambia DONE
- Weller IIP – Kenya and Tanzania
- LeJeune EP - several Central American countries (priorities=Honduras and Guatemala)
- Maredia EP – India NO
- Wien EP – Zimbabwe NO

Priority 3 projects to review (maybe just a desk review):

- Miller IIP – Nigeria NO
- Paull IIP – Sri Lanka DONE
- Raynolds IIP – South Africa

FY14 – Assess Pilot Projects and Centers of Innovation

- Barrett PP – Tanzania DONE
- Scow PP – Uganda
- Trexler PP – Vietnam and Cambodia
- Nienhuis PP – Honduras, Nicaragua, El Salvador, and Guatemala
- Ngouajio PP – Benin and Kenya
- Centers of Innovation – Kenya, Honduras, and Thailand

FY15 – Assess Comprehensive, Focus, and Continuation Projects

- Bradford CP- Nepal, Bangladesh, Kenya, Tanzania, Uganda, & Rwanda
- Weller CP- Kenya, Tanzania, Zambia
- Bonsi FCP- Ghana
- LeJeune FCP- Bolivia, Chile, Ecuador, Guatemala, Honduras, Peru
- Trexler FCP- Cambodia, Vietnam (reports w/ "Creating a niche market" PP)
- Reyes FCP- Cambodia
- Ristaino FCP- Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Mexico, Panama
- Simon FCP- Zambia
- Kornbluth FCP- Honduras, Kenya, Thailand
- Brecht FCP- Honduras & Guatemala
- L. Wheeler FCP- Tanzania, Ghana, Honduras, Guatemala, Thailand

Highlighted projects= need to be evaluated