

# Women-led agroforestry and clean cookstoves in Honduras: Field evaluation of farmer-led gender-transformative strategies for low emissions agriculture

Working Paper No. 125

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Ryan Hottle



RESEARCH PROGRAM ON  
**Climate Change,  
Agriculture and  
Food Security**



Working Paper

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## Abstract

This paper outlines the development of a women-led agroforestry and improved cookstoves project in Honduras. Analysis aims to contribute to learning for future projects, especially projects aiming to improve gender relations. The project intended to increase gender equity among smallholder farmers while reducing greenhouse gas emissions through agroforestry and fuel-efficient stoves. The project was successful due to a) participating farmers' experience with innovation and research; b) engagement of men in women-led activities to enable slow, organic changes in gender relations within the implementing organization, farmers' organizations and households; and c) the strong history, knowledge and working relations that the implementing organization had with farmers on the ground. Areas for improvement include harnessing farmers' knowledge of crop breeding and research to test a wider range of coffee varieties under different conditions, and improving data collection systems. Main technical findings cover topics from micro-catchment to integrated pest management to micro-financing. This report includes an explanation of the community's needs; a description of the technical, social, scientific and economic innovations employed in the execution of the project; and a series of recommendations to aid in the development of future projects.

### Keywords

Improved cookstoves; Gender; Agroforestry systems; Climate change mitigation; Innovation; Honduras

## About the author

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## Acronyms

C	Carbon
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CIALs	Local Agricultural Research Committees
CLR	Coffee leaf rust
CRI	Climate risk index
FIPAH	Foundation for Participatory Research with Honduran Farmers
Ha	Hectare
ICAFFE	Costa Rican Coffee Institute
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
pH	Measure of soil acidity or alkalinity
PROLINNOVA	Promoting Local Innovation (NGO)
PM	Particulate matter
PM-2.5	Particulate matter less than 2.5 micrometers in diameter
SOC	Soil organic carbon
SOM	Soil organic matter
UN	United Nations
USD	United States dollars

## Translations from Spanish

Eco-Justa	Improved “rocket” cookstove
Harmone	Traditional compost mix
Hertos familiares	Household gardens
Hochatchi	Organic fertilizer, cow manure
Minifundistas	Subsistence farmers
Plancha	Flat clay or metal top of stove used to cook tortillas
Postrera	Second rain season from September through October
Primera	First rain season lasting from May through September



## Executive Summary

This report provides a case study and evaluation of a CCAFS-supported action research project to support women's and men's innovation in the design and implementation of improved cookstoves and high diversity agroforestry-coffee systems in the municipalities of Yorito, Sulaco and Victoria in the department of Yoro, Honduras. The project was implemented by the Foundation for Participatory Research with Honduran Farmers (FIPAH); Local Agriculture Research Committees (CIALs) – autonomously run farmer organizations with female and male leadership; and PROLINNOVA. The purpose of the case is to summarize the approach and outcomes of the project.

Honduras is the second poorest country in Central America. It has a per-capita income of 1,880 USD in 2010 (IFAD, 2012). The country ranks 121 out of 187 on the United Nations (UN)'s Human Development Index (HDI). An estimated 63.8 percent of rural households face extreme poverty, lacking basic needs such as clean water, sanitation, and adequate food security (World Bank, 2012). Extreme poverty is largely a rural problem, with the majority of poor living in the hillside areas of the interior. Lack of access to education, medicine, employment and water combined with low agricultural productivity and lack of land tenure create self-reinforcing poverty traps. Rural women, indigenous groups, and the youth are generally the poorest and considered most vulnerable. Women-headed households constitute approximately 9 percent of the country's agriculturalists. According to IFAD (2012), smallholder women farmers make on average 30 percent less than households with men.

The objectives of the project “Women-Led Agroforestry and Clean Cookstoves” were to foster farmer-led innovation (recognizing, supporting and enhancing innovations in agricultural systems already being made by farmers and farming communities while directly involving them in the innovation process in the case of exogenous technologies and practices); promote gender equity by balancing decision making, power, and control of resources by women; and support low-emissions agriculture by transitioning practices toward more sustainable, less-greenhouse gas intensive agricultural practices which simultaneously increase farmer productivity and resilience. The outcomes were measured using a number of empirical data collection methodologies including surveys, soil sampling and laboratory analysis, and field data collection for estimating above- and below-ground biomass carbon.

In the study sites for this project, women have been involved in the construction of “Eco-Justa” model cookstoves to reduce fuel wood use and improve indoor air quality. The stoves cost approximately 1,000 lempiras (48 USD) to construct, making it cost prohibitive without project support. Past studies

have found that the use of improved cookstoves is associated with 63 percent lower levels of particulate matter and 87 percent lower levels of carbon monoxide compared with traditional stoves. Using a survey, the project found that 80% of the surveyed women decreased their consumption of firewood by 50% as a result of the project. The most significant benefits of the cookstoves reported by women during the evaluation were the cleanliness, speed of cooking and reduced fuel wood use.

Agroforestry-coffee systems were established on a total of 16 hectares (ha) of land divided into 49 smaller plots that were planted and managed by women farmers with varying assistance from men in 18 participating communities in Yorito, Sulaco and Victoria. High diversity polyculture agroforestry systems increase household nutrition diversity and resilience, reduce the likelihood of flooding, provide shade to reduce soil moisture losses, increase above- and below-ground carbon pools, fix nitrogen, and provide fuel wood sources. All the agroforestry systems used coffee as the principal understory species, and additionally, diverse fruit tree species, logging and shade/firewood species and condiments, according to the interests of the participating women.

One of the main research aspects of the project was to estimate carbon sequestration within the agroforestry plots. In order to accomplish this, carbon sequestration measurements and estimates were made for both the soil and biomass stocks. Measuring soil and biomass carbon sequestration is an essential strategy if ever the project planned to become part of a voluntary or compulsory carbon market for trading offsets. Four events were carried out with the participation of 65 women and 16 men in four communities to train farmers on the methodology needed to measure biomass and soil carbon, and how to use equipment and field books. Extensive soil sampling was conducted by the CIALs. Overall, the results showed a high degree of heterogeneity between and within communities. The data were not sufficient to show increases in soil or biomass carbon stocks.

An important aspect of the project was providing coffee leaf rust (CLR)- known as “Roya-” resistant strains of coffee to farmers who had had their crops damaged or destroyed by the disease. CLR reached epidemic proportions in 2012, devastating coffee crops across North, South, and Central America including Colombia, El Salvador, Guatemala, Honduras, and Peru. CLR is a fungal disease spread through direct contact of infected plants. While CLR has generally affected lower-latitude coffee production, the disease appears to be spreading at higher latitudes, possibly as the result of climate change. CLR significantly decreased coffee production, reducing an important income source for farmers. The International Coffee Organization (ICO) estimated that in 2012 CLR resulted in the loss of \$500 million and cost 374,000 jobs.

Both women and men farmers considered the availability of improved CLR-resistant varieties of coffee, specifically Lempira and IHCAFE-90, a main feature of the project. While there were obvious

benefits of the new CLR-resistant varieties, the limited genetic diversity may also eventually increase susceptibility to future mutated varieties of coffee rust or other plant diseases altogether. Ojo de Gallo (a fungus, *Mycena citricolor*) and Coffee Berry Borer (*Hypothenemus hampei*) are two other potentially harmful diseases that could negatively impact coffee production, particularly with warming temperatures expected with climate change which is expected to increase the spread of pests and disease. Planting of a single variety of coffee (Lempira) or a limited number of varieties could significantly hamper the resilience of coffee systems to new strains of CLR or new pests and pathogens. One of the main potential improvements to the project and future projects would be to seek greater genetic diversity of coffee varieties and to allow farmers to conduct participatory action research using different varieties of coffee with different management techniques.

Overall the project was viewed to be highly successful. An unofficial measure of this success was how many women farmers were interested in joining the project after they viewed the progress being made by women farmers involved in the project. A key strength of the project was that it will continue to provide benefits for a significant period of time even after the project is concluded. As the coffee plantings mature and as the agroforestry trees continue to grow and bear fruit, the income generation of the women involved, and their households, will continue to benefit.

The following innovations contributed to project outcomes.

- Technological innovations: high diversity polyculture agroforestry systems, rust-resistant, shade-grown coffee, improved cookstoves and the use of traditional and novel organic soil amendments such as compost, manure and lime.
- Social innovations: increased access to, and control over, land for women and youth training. Engaging men in activities led by women had the effect of increasing men's recognition, respect, and support of women led initiatives.
- Scientific strategies: extensive soil analyses and the development of a methodology for calculating above- and below-ground carbon storage increased the long-term contributions of the project and may provide new methods for data collection in the future.
- Economic innovations: direct income provision and greater knowledge and control over household budgets.

The project was not without room for improvement: specifically, the farmer's knowledge of farmer-led crop breeding and research could have been harnessed to test a wide variety of coffee varieties under different conditions, using soil fertility amendments for example. The use of only two varieties of coffee could cause greater vulnerability in the future. Likewise, the selection of agroforestry species seemed, at times, not to reflect the needs or wants of farmers; and some selections seemed inappropriate for the growing conditions. Better data collection systems that use text-based data entry

could allow for easier data transfer, aggregation, analysis and sharing. This, in turn, would allow for better data quality and quantity, and could increase the ability to share research based on these studies.

The project would have benefitted from more robust species selection for agroforestry plantings and established metrics for analyzing project outcomes to enable better assessment of the project. The following threats to the continuation and long-term impacts of the project were identified:

- Possibility of new strains of pests or pathogens
- Lack of maintenance or improper use of stoves
- Lack of carbon pricing or inability to tap into financial incentives for carbon sequestration
- Usurpation of land
- Income and decision-making dominated by male farmers.

The project contributed to the development of farmer-led, gender-transformative research projects in low emissions agriculture, and as such it provides useful guidelines for scaling up low emissions interventions in future projects. Recommendations for improving the project include:

- Increase genetic diversity of the coffee varieties tested
- Capture and re-use coffee-based by-products
- Test rock dusts for viability as fertilizers
- Improve planting techniques
- Incorporate home gardens into the project
- Use integrative pest management strategies for CLR.

The use of real-time internet-based database management was suggested as a way to increase the rigor and usefulness of experiments. Furthermore, “organic,” “fair trade” and “carbon negative” labelling, micro financing and lending circles were suggested for their potential to increase farmers’ incomes. Ideas and critical areas identified in the agricultural and natural resource management sectors show an increased focus on water, micro-catchment and terra-forming projects to prevent soil erosion and improving cooking efficiency through complimentary strategies such as selection and drying of fuel wood.

Overall, the project provides a model low-emissions, climate resilient and gender transformative project. The needs of both women and men farmers were extremely well addressed, evidenced by the fact that many men and women farmers asked to be part of the project. The practices were sustainable and likely to lead to increased resilience of rural households to climate impacts. The benefits will likely be significant and sustainable, as the coffee and agroforestry systems mature. Key factors for the of the project were: the experience of farmers with innovation and participatory research;

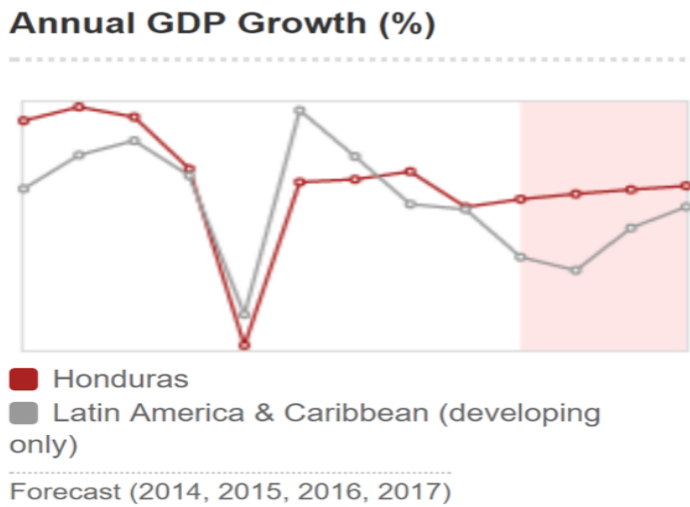
engagement of men in women-led projects that led to slow, organic changes of men extending more recognition, respect and support of women within key social structures (the implementing organization, farmers' organizations and households); the strong history, knowledge and working relations of FIPAH with farmers on the ground; and an extremely well designed and executed project, which took into account the needs of farmers.

## 1. Background

Honduras is the second largest Central American country. It borders El Salvador and Honduras to the west, the Pacific Ocean and Nicaragua to the south and the Atlantic Ocean to its east. It is well endowed with fisheries and arable land, including 1.8 million hectares of cropland and 2.5 million hectares of pasture (FAO, 2001). Approximately 39 percent of the country is forest, and 27 percent is under agricultural production. Nearly 40 percent of the workforce is directly involved in farming; much higher proportions are in rural areas. Much of the land area is covered in mountains, giving rise to the nickname "the Tibet of Central America." The varied topography and microclimates of Honduras makes it an ideal location for diversified production, particularly of high value fruits and vegetables.

Honduras is a low- to middle- income country, with six out of every ten rural households living in extreme poverty, according to the World Bank (2012). While the country has recovered from the global economic recession in 2008 and 2009, with gross domestic product (GDP) increasing at around 2.8 to 3.7 percent per annum, the country continues to be hindered by economic inequality, violence (it has the highest homicide rate in the world), and external price shocks, particularly to the agricultural sector, which has lost two-thirds of its purchasing power mainly due to decreases in key agricultural outputs such as coffee and bananas (World Bank, 2012). Honduras has an estimated population of nearly 7.5 million people, with a mean population density of 65 people per square kilometer (World Bank, 2012). The demographic profile is predominately youthful: more than 34 percent of the population less than 14 years old.

*Figure 1: Annual GDP growth in Honduras, Latin America*



### 1.1. Geography and agricultural production

Honduras is generally divided into three distinct geographical areas: the interior highlands characterized by mountainous terrain where the vast majority of smallholder farmers live, the Caribbean lowlands in the northern region, and the alluvial plains near the Gulf of Fonseca. In the fertile north, banana, sugar cane, and palm oil are widely cultivated, although much of this land and production is controlled by two major multinational corporations, Dole Food Company and Chiquita. Both companies export nearly all of their production. In the south, which experiences more frequent drought, cattle, sugar cane, cantaloupe, and prawns (shrimp) are cultivated. In the central highlands, coffee, beans, maize, timber and cattle are the main agricultural outputs.

*Figure 2: Map of Honduras, showing elevation*



The project was based in the interior highlands, which constitutes around 80 percent of the land area and is where most people live. The elevation of this area varies widely, from 500 to 2,485 meters above sea level, giving rise to a wide gradient of agro-climatic conditions that are mediated by temperature, elevation, and aspect (orientation on the mountain). This results in a wide variety of microclimatic conditions. Much of the land is difficult to traverse or cultivate and therefore has remained poorly developed or with low agricultural yields.

A depression runs from San Pedro Sula eastward to the Gulf of Fonseca providing an important transportation corridor across the country. Flat valleys consisting of grass, shrub, and woodlands are scattered across the highlands, where the majority of settlements (including the capital, Tegucigalpa) and commercial agriculture takes place. Smaller farm operations and subsistence agriculture is relegated to the steeper terrain, where there is less potential for mechanization, poor transport, lack of water, sanitation and electricity, and shallow soils highly susceptible to erosive forces. These factors combine to create significant poverty traps for the people that inhabit the hillsides. The ecological communities in the highland areas are diverse with open woodlands of pine forests, oak, and grasslands in the western and central highland areas. In the east, dense, broadleaf forests occupy much of the terrain. There are fragments of dense rainforest that once dominated the country that can still be found in the highest areas, where land clearing has not taken place.



***Smaller farm operations and subsistence agriculture are relegated to steeper terrain, where there is less potential for mechanization and poor transport, lack of water, sanitation and electricity, and shallow soils highly susceptible to erosive forces. This combination creates significant poverty traps for the people that inhabit the hillsides. Photo: Ryan Hottle.***

For the past several decades, analysts have pointed to Honduras as a country that has the potential for significant growth in the agricultural sector. This is due to a number of factors, including: a substantial proportion of land that continues to be underutilized by, for example, low efficiency livestock operations and traditional management of crops such as maize and beans that tend to result in low yields. For example, Smeltekop et al. (2005) reported that the national bean yield was around 700 kilograms per ha, while yields from experimental trials in research plots gave as much as 2500 kilograms per ha using best management techniques and improved varieties. Another reason for the high estimated potential is the substantial amount of land that is fallow each year. Lastly, the proximity of Honduras to developed countries such as the U.S. and Canada or rapidly developing countries such as Brazil provide opportunity for a strong export market.

## 1.2. Soils

The soils in the highlands, while highly heterogeneous, are relatively poor compared with other Central American countries due to the lack of rich volcanic ash. Many neighboring countries benefited from the deposition of volcanic ash from the “Volcanic Axis,” which provides the parent material for rich “andic” soils characterized by amorphous (non-crystalline) minerals, specifically imogolite and allophane, along with amorphous iron and aluminium minerals which bond strongly with organic matter and therefore provide the basis of strong soil formation and organic matter accumulation. The Volcanic Axis largely bypasses Honduras: only the Western plateaus received significant ash deposition. Much of the rest of Honduras has soil that is characterized by a high degree of weathering, low activity clays, low cation exchange capacity (CEC), and low levels of soil organic matter (SOM) accumulation. Soils of Honduras include orthic and plinthic acrisols; chromic, humic, calcic and dystic cambisols; rendzinas; ferric luvisols; gleyic luvisols; and dystic nirosols (Timms, 2007).

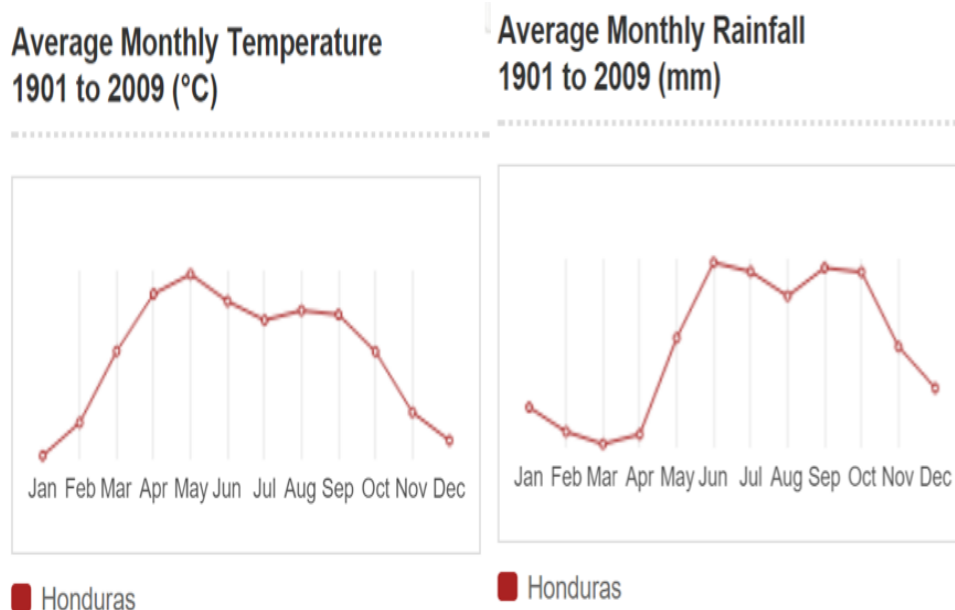
More than 80 percent of land in Honduras has slopes exceeding 20 percent (Thurow and Smith, 1998) and is considered to be highly erodible. Cárcamo, Alwang, and Norton (1994) estimated that cultivated soils in Honduras were losing soil at rates of more than 300 tons per ha per year. The maximum rate of soil formation in the tropics is considered to be 1 ton per ha per year and, thus, such large rates of erosion are highly unsustainable. Inequities in land distribution and tenure have resulted in resource-poor farmers occupying much of the steep terrain, which is highly vulnerable to soil erosion particularly after mechanical cultivation or shifting cultivation (“slash-and-burn”) agriculture. As soils are eroded, subsistence farmers (“*minifundistas*”) are often driven to clear more land for cultivation, further exacerbating the degradation process and undercutting food security.



### 1.3. Climate and climate change

Honduras has bimodal rainfall pattern with two distinct growing seasons: the first growing season “Primera” which has the highest level of rainfall (around 720 mm) and the second “Postrera” which has less (~560 mm) which quickly diminishes. Subsistence farmers often plant using a relay system with the vast majority of maize (*Zea mays*) planted during Primera, followed by common bean (*Phaseolus vulgaris L.*) during Postrera. Approximately 60 percent of beans are grown during the Postrera season due to their relatively short maturation period (Rosas, Erazo, and Moncada, 1991). Droughts in either of these seasons can greatly diminish productivity and lead to increased food insecurity. Droughts are categorized into two types within the semi-arid tropical regions of the world including Honduras: terminal (end-of-season) drought through which which the crop relies on banked soil moisture for flower production and seed filling, and intermittent drought, which is less predictable and depends largely on climatic conditions. Strategies to increase water-holding capacity (WHC) and moisture retention within the soil profile can hedge against terminal drought, whereas intermittent drought is more difficult to deal with. Already an increase in temperature of 0.7 to 1°C has been observed throughout Central America. This is likely to increase evapotranspiration rates, decrease soil moisture and lead to increased crop stress particularly during times of drought. While no significant changes in annual precipitation have been found, there has been a trend toward increasing frequency of both drought and high rainfall events that appear to becoming more intense (IPCC, 2013).

**Figure 3: Average monthly temperature and rainfall in Honduras**



The geographical location of Honduras between the Atlantic and Pacific oceans makes it extremely vulnerable to a variety of climatic conditions, including tropical storms, flooding, droughts, sea level

rise and hurricanes (i.e. cyclones). Honduras also tends to be strongly impacted by changes in sea surface temperatures and oscillations in oceanic warming, such as the El Nino Southern Oscillation (ENSO) and the Atlantic Multidecadal Oscillation (AMO). Whether the intensity and/or frequency of cyclonic activity in both the Atlantic and Pacific is likely to increase due to climate change has been a hotly debated topic within the scientific research community. Recent studies have found a likely increase in the intensity of cyclones and an increase in frequency of intense cyclones despite potential decrease to total cyclone activity (Knuston et al., 2010)<sup>1</sup>.

In October 22, 1998, on the tail end of 1997/1998 El Nino event (which was the most powerful El Nino ever recorded), Hurricane Mitch struck the Honduras mainland from the Atlantic on October 29. As much as 928 mm of rainfall fell, causing severe flooding, landslides, and road cuts. An estimated 1.5 million people were left homeless, 70 percent of the population was left without drinking water, 70 percent of the transport infrastructure was destroyed and damaged, crop exports dropped by 9.4 percent, and 7,000 fatalities were reported. The total direct economic damages were estimated at more than 2 billion USD and another 1.8 billion USD in indirect damages.

According to a 2013 report by Germanwatch, formulators of the Global Climate Risk Index (CRI), Honduras, Myanmar and Nicaragua were the countries most affected by extreme weather events from 1992 to 2011 (Kreft et al., 2014). Honduras experienced 60 extreme weather events and an estimated 329 climate change-induced deaths per year.

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<sup>1</sup> “[F]uture projections based on theory and high-resolution dynamical models consistently indicate that greenhouse warming will cause the globally averaged intensity of tropical cyclones to shift towards stronger storms, with intensity increases of 2–11% by 2100. Existing modelling studies also consistently project decreases in the globally averaged frequency of tropical cyclones, by 6–34%. Balanced against this, higher resolution modelling studies typically project substantial increases in the frequency of the most intense cyclones, and increases of the order of 20% in the precipitation rate within 100 km of the storm centre. For all cyclone parameters, projected changes for individual basins show large variations between different modelling studies” (Knutson et al., 2010).

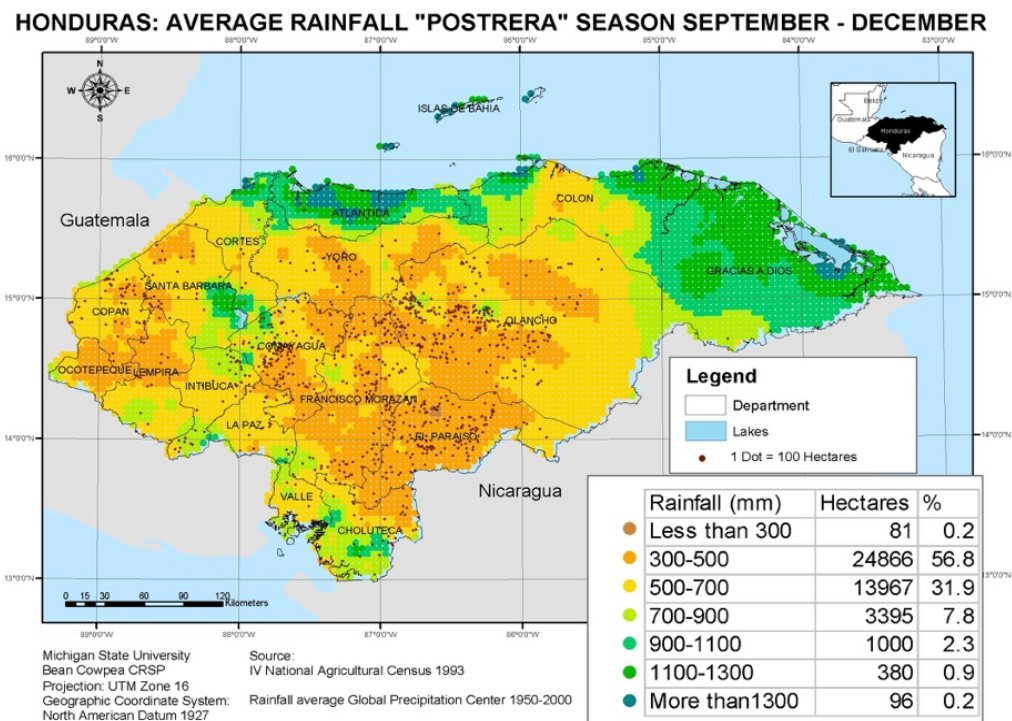
Table 1: Long-term Climate Risk Index (CRI) between 1992-2011 finds Honduras the most impacted country in the world

CRI 1992-2011 (1991-2010)	Country	CRI score	Death toll	Deaths per 100,000 inhabitants	Total losses in million US\$ PPP	Losses per unit GDP in %	Number of Events (total 1992-2011)
1 (3)	Honduras	10.83	329.25	4.96	679	2.84	60
2 (2)	Myanmar	11.00	7,137.25	13.79	640	1.41	37
3 (4)	Nicaragua	18.50	160.0	2.82	223	1.89	44
4 (1)	Bangladesh	20.83	824.4	0.58	1,721	1.18	247
5 (5)	Haiti	21.17	301.1	3.43	148	1.08	54
6 (6)	Viet Nam	23.67	433.15	0.55	1,741	1.06	214
7 (9)	Korea, DPR	26.00	76.65	0.33	3,188	7.64	37
8 (8)	Pakistan	30.50	545.9	0.38	2,183	0.73	141
9 (55)	Thailand	31.17	160.4	0.26	5,413	1.38	182
10 (7)	Dominican Republic	31.33	211.6	2.47	185	0.35	49

et al., 2014)

Source: (Kreft

Figure 4: Rainfall in Honduras September-December



## 1.4. Poverty and gender

Honduras is the second poorest country in Central America. It had a per-capita income average of 1,880 USD in 2010 (FAO, 2012). The country ranks 121 out of 187 on the United Nations (UN) Human Development Index (HDI). An estimated 63.8 percent of rural households face extreme poverty lacking basic needs such as clean water, sanitation, and adequate food security (World Bank, 2012b). Despite high levels of poverty, Honduras has made progress with the proportion of the population in poverty dropping from 61.5 percent in 1991 to 47.5 percent in 2006 (World Bank, 2012b). Most of the gains, however, have been made in urban areas. Extreme poverty is largely a rural problem: the majority of poor live in the hillside areas of the interior. Lack of access to education, medicine, employment and water combined with low agricultural productivity and lack of land tenure create poverty traps.

Rural women, indigenous groups, and the youth are generally the poorest and considered most vulnerable. Women-headed households constitute approximately 9 percent of the country's agriculturalists. According to FAO (2012), smallholder women farmers make on average 30 percent less than households with men. An estimated 71 percent of indigenous communities are impoverished; they work either as farm labor for land owners or move from tract to tract as subsistence farmers (FAO, 2012).

Women in rural communities face the additional burden of domestic labor, isolation, and low-levels of education, literacy, and self-esteem. They are frequently tasked with caring for dependents, collecting fuel wood and water, meal preparation, and growing fruits, vegetables and grains in home gardens (*hertos familiares*). In coffee-growing regions they are expected to pick cherries from the bushes during the harvest period with little or no compensation from men who tend to control cash crops. Only 2 percent of land titles in Honduras have been allocated to women, and there is often minimal financial services available for services like loans to start up small businesses (FAO, 2012). Gender-based violence is also disturbingly common throughout Honduras and Latin America, as a whole often referred to as "*femicidios*" (femicide). Gender disparity is likely to limit poverty reduction, as gains in economic growth are often hampered when large inequalities exist (Bourguignon, 2002). Discrimination both within and outside households can therefore impede poverty alleviation and economic growth.

## 2. Farmer perceptions

During the project evaluation informal interviews with farmers (both women and men) and farmer groups were conducted. The interviews revealed that water quality and quantity, access to markets and fair prices, competition from wealthy land owners, the impacts of climate change, and pests and diseases (principally coffee leaf rust or “Roya”) were among the most significant concerns. These findings were similar to those found by Hellin and Haigh (2002) in a questionnaire administered to 213 smallholder farmers which found pests and disease, drought and irregular rainfall, low productivity, quality of land, availability of land, and lack of economic resources were considered to be among the principle challenges. See Table 2.

**Table 2: Farmers’ perceptions of threats to agricultural production based on a questionnaire administered to 213 smallholder farmers in Honduras**

Threat	Responses	Percentage of responses
Pests and diseases	172	38
Drought and/or irregular rain	136	30
Low productivity	60	13
Quality of land (eroded, waterlogged etc.)	40	9
Availability of land	29	7
Few economic resources	7	2
Others	4	1

Source: Hellin and Haigh (2002)

### 2.1. Water quantity and quality

In project areas visited by the evaluator, farmers reported that the most critical need for most farming communities was water quantity and quality for direct consumption and irrigation. Farmers explained that contamination of upstream water sources from human waste caused water contamination negatively impacting human health in many households. Communities also voiced a related concern that large coffee plantations would require large quantities of water for removing coffee cherries from the pulp. This process could provide for a compostable organic, but often ends up polluting local waterways, thus further limiting the supply of fresh water, particularly for downstream users. One farmer predicted that the many plantations coming into maturity in the next two-to-three years would dramatically increase water demand. In several villages there was only a single water tank for the entire community to use, which raises the question as to how increasing demands for water will be met.

## 2.2. Access to markets and fair prices for farm products

Maize and beans, as well as agroforestry crops such as bananas (*Musa*), papaya (*Carica papaya*), pepper (*Piper nigrum*), support household food security and sometimes income generation. For some farmers, coffee represent as much as 70-80% of household incomes, although there were many farmers who did not grown coffee at all. Challenges such as mountainous terrain, poor roads that reduce vehicle speed, and lack of vehicle ownership combine to make the transportation of farm products to market difficult and relatively expensive. Often farmers reported not receiving a fair price for their crops and having little control over price gauging.

## 2.3. Competition from large-scale plantations

Competition from large-scale plantations—specifically coffee plantations—was raised as a significant concern by many farmers in the target communities. First, many farmers expressed concern that coffee plantations owned by wealthy landowners who mainly live in the city were the cause of significant environmental problems. Many of the large-scale plantations were established through complete denudation of the landscape, followed by replanting of a coffee monoculture without any sort of vegetation. Farmers explained that this has caused mass erosion and sedimentation of drinking water. They also worried that such a massive expansion could lead to water shortages as significant quantities of water are needed during the process to refine the cherry (the freshly picked coffee) to a green bean (ready for roasting).

Second, large-scale plantations caused increased competition for market access. Owners of large-scale plantations have greater access to wealth and resources, for example, and can afford to replant with more expensive rust-resistant varieties of coffee and pay for transportation to market.

## 2.4. Impacts of climate change

Many communities raised the issue of climate change, particularly in reference to the timing and strength of rains. Adequate rainfall is especially critical at planting, growth, and harvesting phases, but excessive rainfall can wash away seeds, lead to “dampening off” or rotting of newly emerged plants, or create field conditions difficult to plant or harvest. Some farmers reported experiencing more days of intense sunlight, while others said rainfall was becoming less predictable. It was difficult to determine whether the concerns resulted from farmers’ own observations or as a result of the educational workshop, the evaluation process itself, or having been told the purpose of the visit. In any case, the farmers appeared aware of climate change and understood the potential problems that may likely result. Some farmers collect meteorological data (rainfall and temperature) as part of the participatory seed-breeding program. Data collection by farmers could be a key entry point into

greater thinking about climate change and adaptation strategies. A list of the climate impacts reported by farmers is found in Appendix 2.

## 2.5. Pests and pathogens

In interviews, many farmers in the CIALs reported that coffee makes up as much as 70-80% of their earned annual income, although not all farmers reported growing coffee. They expressed concern that pests and diseases—particularly CLR—may negatively impact production, possibly exacerbated by climate change. Coffee diseases and pests, such as CLR, decreased yields by 40-80% across much of Honduras in 2012, having a devastating impact on livelihoods and food security. Rainy conditions, for example, provide a better environment for transport and infestation of bacterial and fungal diseases. Most farmers reported that they often can't afford fungicides to treat crops and are therefore at greater risk than large coffee plantations when new strains of pathogens attack crops.

## 3. Project overview

### **The objectives of the project were:**

1. Farmer-led innovation: to recognize, support and enhance innovations in agricultural systems already being made by farmers and farming communities while directly involving them in the innovation process in the case of exogenous technologies and practices.
2. Gender equity: to balance decision making, power, and control of resources by women.
3. Low-emissions agriculture: to transition to more sustainable, less-greenhouse gas intensive agricultural practices which simultaneously increase farmer productivity and resilience.

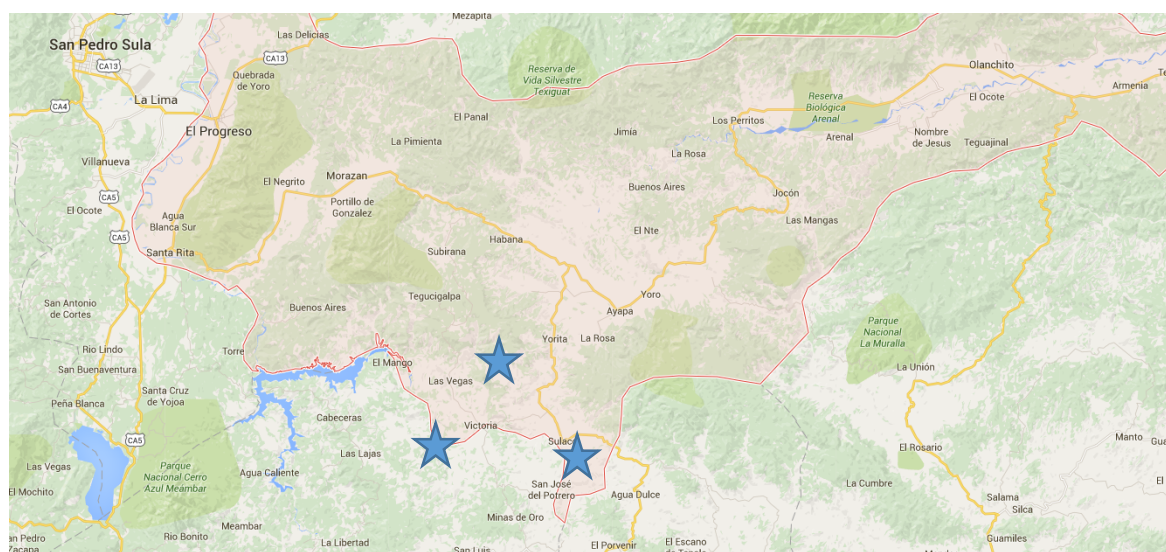
All of the project participants are organized in Local Agricultural Research Committees (CIALs), base organizations that form part of the Association of Local Agricultural Research Committees of Yorito, Sulaco, and Victoria (ASOCIAL Yorito, Suaco, and Victoria).

The CIALs, with coordination from FIPAH, conducted research on improved cookstoves and woman-managed shade-grown agroforestry systems. Two workshops were developed for the planning and design of the agroforestry plots. Women and men discussed climate change, the vulnerability of affected groups, and impacts on food security and on local economies. The workshop also provided information on species selection, allowing the women to select which type and how many trees to plant. The intention was that women would have control over the tenure of these plots and the resulting income stream from the coffee (a significant cash crop) and the agroforestry species including plantains, avocado, pepper and other condiments, as well as species for fuel wood, timber

and nitrogen fixation. Workshops provided training for farmers and student interns to test for above and below ground carbon pools in order to calculate carbon sequestration over time. Samples were analyzed and organic matter contents were found for the baseline sample.

In total the project engaged 49 women in the design and implementation of climate change-related experiments using stoves and agroforestry systems.

**Figure 5: Map of project locations of Yorito, Sulaco, and Victoria in the department of Yoro**



FIPAH’s work aims to support larger socioeconomic and environmental goals. Over the past several decades, many researchers, organizations, and institutions have shifted their focus from projects and programs that aimed to maximize the productivity of farmers (e.g. yield per ha) to addressing larger challenges including socioeconomic and environmental goals such as poverty alleviation, increasing resilience particularly of vulnerable populations, improved food security, human health and nutrition, increasing ecological health and biodiversity, climate change mitigation, and so forth. This shift in focus has generally been viewed as a critical reprioritization within the fields of agriculture and sustainable development to focus on more meaningful outcomes that in the past had been largely ignored or simply unaccounted for.

The reprioritization toward larger socioeconomic and environmental goals, while widely recognized as vital, also presents challenges and adds complexity in designing, evaluating, and measuring projects because the interventions and innovations seek not merely to increase yield, but to address more complex challenges that can have unpredictable and sometimes unintended impacts. Such a focus requires understanding not only of agronomy and soils but also of rural development, sociology,



ecology, climatology, gender studies, among others, and ideally a strong working knowledge within many fields and an integration of these knowledge sets. This project aimed to incorporate those goals.

### 3.1. Agroforestry systems

A main objectives of the project was the establishment of fruit, condiment and timber plantings integrated with shade-grown coffee on a total of 16 ha of land divided into 49 smaller plots that were planted and managed by women farmers with varying assistance from men in 18 participating communities in Yorito, Sulaco and Victoria.

Species planted in the project area included peach (*Prunus persica*), lemon (*Citrus lemon*), mandarin (*Citrus reticulata*), orange (*Citrus sinensis*), nance (*Byrsonima crassifolia*), allspice (*Pimenta dioica*), cinnamon (*Cinnamomum verum*), Spanish cedar (*Cedrela odorata*), *Inga* (*Inga niopo*), and mahogany (*Swietenia macrophylla*). All the agroforestry systems used coffee as the principal understory species, and added diverse fruit tree species, logging and shade/firewood species and condiments, according to the interest of the participating women. In addition to providing participants with the benefits of shade-grown agroforestry plots, the high diversity polyculture agroforestry systems provided models to the larger community. One female farmer stated, “*I want to show that women can do this. I want to show them that we can do it, and we can do it sustainably without the need for expensive and harmful chemicals.*”

High diversity polyculture agroforestry systems reduce the likelihood of floods and soil water evaporation, increase above- and below-ground carbon pools, fix nitrogen and provide fuel wood sources. On average they can lead to the net accrual of biomass 5 to 10 times the biomass of conventional cropping systems (IPCC, 2000), although this is highly dependent on conditions such as climate, tree species, planting density, soil type, and management strategies (Nair, 1993). Small-scale agroforestry systems in the tropics can sequester 1.5-3.5 tons of carbon per hectare per year (Montagnini and Nair, 2004). In addition to cycling and storing greater amounts of carbon than traditional annual monoculture row crops, agroforestry systems are also capable of producing diverse outputs, including highly nutritious fruit and nut crops, medicines, edible fungi, saps and resins such as latex, timber and raw materials for craft and construction, and many other non-timber forest products. Many species of leguminous trees such as *Inga* fix atmospheric nitrogen, thereby increasing nitrogen available to plants. Returning organic carbon from trees in the form of leaf litter, prunings, and fine and coarse roots can enhance soil organic carbon (SOC) levels far beyond what cropland alone is capable of, thereby increasing the potential productivity of the given piece of land. Difficulty extracting and quantifying root biomass presents significant uncertainties, yet it is well understood

that root systems (which make up 30% or more of total tree biomass) likely contribute large quantities of carbon to deep soil layers (Young, 1997).

Agroforestry systems may also provide a hedge against negative effects of climate change, as tree crops are often more resilient to extreme weather conditions including droughts and flooding. The canopy structure of agroforestry systems greater reduces raindrop impact, increases water infiltration into the soil profile and decreases runoff. Because trees have deeper root structures, they are often able to extract nutrients and water from lower layers of the soil, thereby decreasing competition with shorter rooted annual crops (Nair, 1993). Trees also buffer from drought stress by creating shaded microclimates that reduce evapotranspiration and conserve soil moisture. These benefits may be extremely important in the context of Honduras, considering the already high soil erosion rates—which have been reported to be as much as 300 tons per ha per year—and possible increases in the frequency and/or intensity of heavy rain events and droughts.

In some cases, women decided to plant further away from their homes either because that was the only location land was available or because higher elevations would better suit coffee production. In some cases, women made the decision to locate fruit trees near the house, setting them apart from the rest of the agroforestry system, both for convenience and to prevent pilfering of fruit. In other cases, the family will move from their communities at harvest time to where the agroforestry plot is located. This is a common practice amongst families who own coffee in the region.

In the municipality of Victoria, 24 agroforestry plots were established with a total area 8.15 hectares. Ten of the plots were located less than 500 meters from people's homes, while the other 14 were located further from homes. The location of planting depended mainly on access to sufficient land. In the municipality of Sulaco, 8 plots were established in five communities, with a total area of 2.8 hectares. Of the 8 plots, only 3 were located less than 500 meters from the house. To access the other plots, the women have to walk more than 30 minutes. In the municipality of Yorito, 17 agroforestry plots were established with 17 women farmers, in an area of 5.12 hectares. Of the 17 plots established, 6 of them are located at less than 500 meters from the house.

The plots for agroforestry that were near homes included fruit trees that give fruit at different times of the year and have high value. Far away plots were more likely fuelwood species integrated with coffee trees in more mountainous terrain. The distant plots were located where land was available to land-poor farmers, especially women. They planted where they had relatives who could watch the trees and protect the harvest, or the families would go and camp out at harvest time. If their plots were successful, men would allocate space within plots closer to home for some tree-planting.

While the benefits of the project were many, many women undertook a heavy labor burden to test the viability of their innovations, with variable support from the men in their families. In some cases, sons, husbands, brothers, and fathers assisted with site clearing and planting (the most burdensome tasks). In other cases, women farmers did the vast majority or all of the work. Some women reported the work being challenging and being largely unaccustomed to the labor. Others took great pride in showing the community what they could achieve on their own.

The agroforestry component of the project was not without room for improvement. It appeared that women farmers had limited ability to actually design agroforestry systems and to select varieties of species to be planted, as nearly all of the women chose similar, if not exactly the same, types of plantings. Some of the species selected (particularly the citrus varieties and peach) appeared to be particularly ill-suited to the growing conditions, and in some cases there was relatively high mortality rates.

### **3.2. Rust-resistant, shade-grown coffee varieties**

An important aspect of the project was providing CLR-, or Roya-, resistant strains of coffee to farmers who had had their crops damaged or destroyed by the disease. CLR reached epidemic proportions in 2012, devastating coffee crops across North, South, and Central America including Colombia, El Salvador, Guatemala, Honduras, and Peru. CLR is a fungal disease spread through direct contact of infected plants. While CLR has generally affected lower latitude coffee production, the disease appears to be spreading at higher latitudes, possibly as the result of climate change.

CLR significantly decreased coffee production, reducing an important income source for farmers. In 2012 and 2013, Peru and Guatemala, respectively, declared states of emergency. Large crop losses across Central America and Caribbean countries led to all-time price highs, as too few resources, ignorance of early warning signs, insufficient and inaccurate fungal treatments, poor training, lack of infrastructure and conflicting scientific recommendations combined to limit swift, effective actions. The International Coffee Organization (ICO) estimated that in 2012 CLR resulted in the loss of \$500 million and cost 374,000 jobs.

Rust-resistant, shade-grown coffee varieties (Lempira and IHCAFE-90) significantly reduce the risk of Roya, but they are generally considered to be “less quality” coffee varieties due to their relatively high acidity and the acidity’s impact on taste. An additional concern, discussed below, is that planting only one or two varieties of coffee could create future problems by setting the stage for more coffee disease and pests to flourish.

Farmers considered the availability of improved CLR-resistant varieties of coffee, specifically Lempira and IHCAFE-90, a main feature of the project. While there were obvious benefits of the new CLR-resistant varieties, the limited genetic diversity may also eventually increase susceptibility to future mutated varieties of coffee rust or other plant diseases altogether. Ojo de Gallo (a fungus, *Mycena citricolor*) and Coffee Berry Borer (*Hypothenemus hampei*) are two other potentially harmful diseases that could negatively impact coffee production, particularly with warming temperatures expected to increase the spread of pests and disease. Planting of a single variety of coffee (Lempira) or a limited number of varieties could significantly hamper the resilience of coffee systems to new strains of CLR or new pests and pathogens.

A main potential improvement to this and future project would be to seek greater genetic diversity of coffee varieties and to allow farmers to conduct participatory action research using different varieties of coffee with different management techniques. For example, a farmer may plant 3-5 different types of coffee using randomized block design and then report on yield, disease resistance, time to fruiting, and other key parameters of the varieties. This would be useful in future plantings, depending on soil type and elevation. More diverse plantings may also hedge against future outbreaks. The Central Coffee Research Institute in Balehonnur, India has developed multiple CLR-resistant strains (e.g. Sln 5-A, Sln 5-B, Sln 6, Sln 9, Changraka) that may be worth testing alongside Lempira and IHCAFE-90. The Costa Rican Coffee Institute (ICAFFE) has also developed a CLR-resistant variety called Obata that is reported to have a similar quality to 100% Arabica varieties, while providing predictable and homogenous yields. Presented with this suggestion, a FIPAH staff



***One of the most motivating factors of the project was that it provided coffee varieties resistant to coffee leaf rust (CLR), specifically Lempira and IHCAFE-90. Here a new CLR resistant variety planted with project funds is next to a matured non CLR-resistant variety. (Photo: Ryan Hottle)***

member replied that, “getting access to numerous coffee varieties would be very challenging in Honduras. ICAFE [Instituto Hondureño del Café] manages coffee in Honduras, including all the varieties. Moreover, given the very limited amount of time to get the funding spent, further research would have been impossible.” Certainly, given limited time and resources as well as the benefit of hindsight, it is apparent that the recommendation of incorporating and testing a large number of varieties would be difficult.

### 3.3. Improved cookstoves

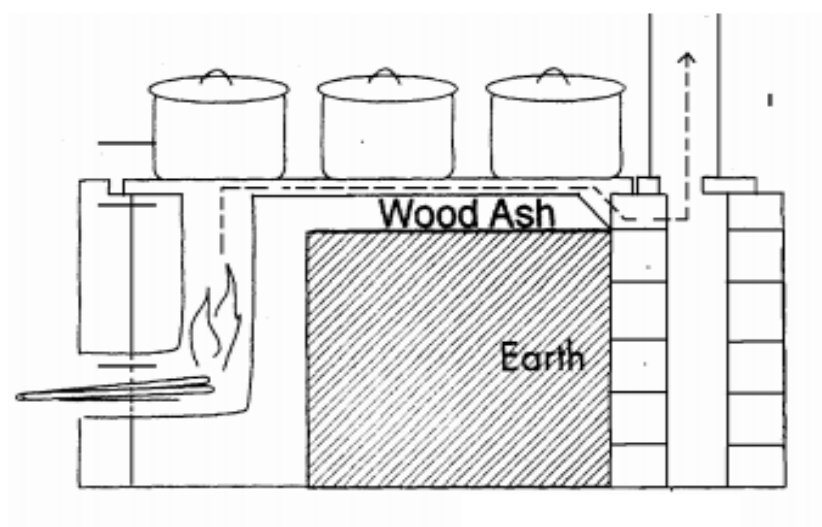
Many people in developing countries rely upon traditional biomass for cooking and heating and are, as a result, exposed to extremely high levels of indoor air pollutants, including black carbon soot, carbon monoxide, nitrogen oxides, polycyclic aromatics, and dioxins. These products of incomplete combustion have been linked to pulmonary-cardiovascular disease, myocardial infarctions, eye infections, and chronic obstructive pulmonary disease resulting in an estimated 1.8 to 2.0 million deaths per year. This is more than HIV/AIDS (1.8 million per year), tuberculosis (1.3 million), diabetes (1.3 million), traffic accidents (1.2 million), and malaria (0.7 million). The impacts of poor indoor air quality from traditional cooking predominately impacts women, who are nearly always tasked with food preparation, and children. Practically all the mortalities occur in developing countries—approximately half the mortalities are children under the age of five. By 2050, the number of deaths per year is expected to rise to 3.6 million.

Disaggregated data on the health impacts of cooking and heating with biomass for Honduras could not be found for the country level. Clark et al. (2009) conducted a cross-sectional survey of 79 Honduran women cooking with traditional and improved cookstoves in which they monitoring of carbon monoxide and particulate matter of less than 2.5 micrometers in size (PM2.5). The study found that the use of improved cookstoves was associated with “63% lower levels of personal PM2.5, 73% lower levels of indoor PM2.5, and 87% lower levels of indoor carbon monoxide as compared to traditional stoves. Women using traditional stoves reported symptoms more frequently than those using improved stoves.”

The project used the “Eco-Justa” model cook stove, a rocket elbow-type stove named after Doña Justa Nuñez of Suyapa, Honduras, who helped to design it. The stove is one of many versions often referred to as “rocket stoves”. The Eco-Justa is a relatively simple stove constructed around an insulated, “L” shaped combustion chamber which increases the high heat temperature and oxygen availability, therefore leading to a cleaner burn and producing fewer products of incomplete combustion associated with deteriorated indoor air quality. The cleaner burn and greater transfer of heat leads to less fuel being burned. The Eco-Justa stove is formed from two ceramic cylinders made of a mixture of clay,

manure and tree resin. Ashes are often used for insulation. A sealed metal cooking surface or “*plancha*” sits above a stove made of bricks, and a chimney carries the smoke outside. Other models of rocket stoves may have holes in the *plancha*. Under the chimney, a flue collects the soot and ashes and needs to be cleaned periodically. Tortillas can be directly cooked on the surface of the metal *plancha*, and other food can be cooked in pots and pans. The stoves were often built to accommodate firewood to be stored underneath the stove, which helps the drying process.

**Figure 6: The two or three-pot Eco-Justa model is one of the most tried and tested models of improved stove designs**



Source: <http://www.aprovecho.org/>

The improved cook stoves cost around 1,000 lempiras (~48 USD), with the steel portion of the stove costing around 700 lempiras (~31 USD). Most of the components (brick, sand, manure, ash, and cement) could be acquired locally: the stove pipe and metal *plancha* constitute the greatest costs. According to FIPAH’s findings, “An evaluation of the Eco-Stoves showed that 80% of the surveyed women had decreased their consumption of firewood by 50%.” The most significant benefits of the cookstoves reported by women during the evaluation were (1) decreased cooking time, (2) increased cleanliness, and (3) decreased fuelwood use, which also meant less time spent gathering fuel wood. One woman from the La Esperanza CIAL reported that, “The improved stoves are more beautiful and help keep the kitchen cleaner.” In Guachipilin, many women have to travel long distances to collect fuel wood, so the decrease in the use of wood had an important impact on decreasing drudgery and increasing time for other activities.

Not all women reported that the stoves actually reduced fuel wood use, yet they said they were happy with their stove mainly because it took less time to prepare a meal and because it made the house much cleaner and more comfortable since there was less smoke, ash and soot deposited in the house.

Many women reported difficulty using the improved cookstoves until training was provided on maintenance issues. Training focused on removing ash and cleaning out the combustion chamber.. Once they received the proper training, users reported having no problems and viewed the stoves favorably. Two women farmers from a CIAL shared that other women in their community wanted to join the CIAL once they saw the benefits of the project. “They only want to join the CIAL now because we are getting these stoves.” They added that they had to do a lot of work for many years to be part of the CIAL. This comment demonstrates that the stoves were considered desirable, since other women outside of the CIALs wanted them. One of the FIPAH organizers commented that the women were not nearly as interested in the establishment of agroforestry plots as they were in the improved cookstoves, but that the stoves provided the impetus for them to try agroforestry. It should be noted that the stoves were generally unaffordable for most households, without assistance from the project.

Some women farmers not only learned how to build the stoves, but they also made modifications to the stove design to better suit their needs. FIPAH reported that, “an oven was added and then re-designed to make it more compact, and thus more effective in cooking food and keeping it warm, and more efficient in using fuel. Four women involved in the project generated income from the construction of the stoves. At the same time, financial mechanisms were identified which could push forward the diffusion of this technology led by women of the community.” One woman interviewed during the evaluation process reported she had started her own small business by building Eco-Justa model cookstoves for neighbors in her community after having participated in the construction of her own stove during the project. At the time of the evaluation she said she had constructed more than 20 cookstoves, earning extra income in the process. She planned to build more in the future, as they were extremely popular within her community.

A survey conducted among the participants to assess the use and effectiveness of the improved stoves found that 80 percent of the women surveyed reported a decrease in fuel use by 50 percent. While it was likely beyond the scope of the project, the use of empirical data-gathering would have benefitted the evaluation of the efficacy of cookstoves in decreasing fuel wood consumption and/or decreasing indoor air pollution. Fuel wood demand could have been monitored by women by estimating daily/weekly usage either using a baseline or control group to measure changes in consumption as a requirement of having been involved with the project. Many technologies, such as particulate matter

and carbon monoxide monitors, that have emerged in recent years could provide data on exposure to air pollutants from cooking.<sup>2</sup>

### 3.4. Monitoring soil and biomass carbon sequestration

Mitigation of climate change in the agricultural sector can be delivered either through reduction in emissions from increased fertilizer efficiency or decreased fossil fuel emissions (for example) or through carbon sequestration, which decreases atmospheric carbon dioxide (CO<sub>2</sub>) concentrations by increasing carbon stocks in soils or biomass. As discussed earlier in this paper, agroforestry systems are generally able to cycle and store much higher levels of carbon than conventional annual monoculture systems. Thus, a main research aspect of the project was to estimate carbon sequestration within the agroforestry plots. To accomplish this, carbon sequestration measurements and estimates were made for both soil and biomass stocks. Measuring soil and biomass carbon sequestration is an essential strategy if the project planned to become part of a voluntary or compulsory carbon market for trading offsets.

The project team trained 65 female and 16 male farmers in four communities on the methodology needed to measure biomass and soil carbon and how to use equipment and field books. Extensive soil sampling was conducted by the CIALs, which was then analyzed by labs at the Fundación Hondureña de Investigación Agrícola (FHIA). Soil samples were collected at a 30 cm depth from the surface. Soil organic carbon was reported as soil organic matter (SOM) which, by standard practice, contains 58 percent total organic carbon (TOC)<sup>3</sup>. The project, however, used a factor of 29 percent to convert between SOM and TOC. (See Appendix 9 for soil analysis results). Other soil characteristics measured included pH, N, P, K, Mg, Ca, S, Fe, Mn, Cu, Zn, and B.

Overall, the results showed a high degree of heterogeneity both between and within communities. In the municipality of Victoria, 24 soil samples and analyses were conducted. The results of the analyses

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<sup>2</sup> See for example:

University of California Air Quality Monitoring Group. <http://berkeleyair.com/>  
Litton CD, Smith KR, Edwards R, Allen T. Combined optical and ionization measurement techniques for inexpensive characterization of micrometer and submicrometer aerosols, *Aerosol Science and Technology*, 38:1054–1062, 2004.  
Edwards R, Smith KR, Kirby B, Allen T, Litton CD, Hering S. An Inexpensive Dual-Chamber Particle Monitor: Laboratory Characterization, *Journal of the Air and Waste Management Association*, 56:789-799, 2006.  
Chowdhury Z, Edwards R, Johnson M, Shields KN, Allen T, Canuz E, Smith KR, An inexpensive light-scattering particle monitor: field validation, *J. Environ. Monit.*, 9: 1099–1106, 2007.

<sup>3</sup> Total organic carbon (TOC) is the carbon (C) stored in soil organic matter (SOM). Organic carbon (OC) enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms, and soil biota. SOM is the organic fraction of soil exclusive of nondecomposed plant and animal residues. Nevertheless, most analytical methods do not distinguish between decomposed and non-decomposed residues. SOM is a heterogeneous, dynamic substance that varies in particle size, C content, decomposition rate, and turnover time. Soil Organic Carbon (SOC) is the main source of energy for soil microorganisms. The ease and speed with which SOC becomes available is related to the SOM fraction in which it resides. In this respect, SOC can be partitioned into fractions based on the size and breakdown rates of the SOM in which it is contained (see table 1). The first three fractions listed are part of the active pool of SOM. Carbon sources in the active pool are relatively easy to break down. SOM contains approximately 58% C; therefore, a factor of 1.72 can be used to convert OC to SOM. There is more inorganic C than TOC in calcareous soils. TOC is expressed as percent C per 100 g of soil.



indicate that in the parcels located in 6 of the communities of this municipality, the average % C in the OM of the soil is 2.10%, which is above that of the soils in the plots located in the other municipalities in the study. The community of Urracal had average % C values of 3.53, which had the highest carbon contents, likely a product of the use of plots located in the forest area for the establishment of the agroforestry systems. In La Fortuna, soil samples analyzed reflect a tendency of the soils to have more acidic pH levels (4.9-6.4), with average pH of 5.28. These values are influenced by the agro-climatic conditions of the community, notably precipitation above 2500 mm annually leading to more rapid leaching and acidification. The results from soil analysis carried out on 8 farms located in the municipality of Sulaco, demonstrate an average of 1.78 % C of the soil, values that are much lower than in the plots in Victoria. In Higuerito, three farms had average values of 2.33 % C, which is considerably higher than the sampled municipal average. In relation to pH, in general the soils of the municipality of Sulaco show a tendency to be slightly acid (average=6.4).

Above- and below-ground biomass was estimated using a rapid assessment method from empirically gathered data. The methodology for the estimation of carbon stored in the biomass of the trees in the agroforestry plots was carried out using a method of rapid measurement consisting of:

- Measurement of 2 sample points inside the plot of  $\frac{1}{2}$  Manzana (Manzana=0.7 hectares.) or 4 in a plot of 1 Manzana in a diameter of 15 meters.
- Inside of this plot, the height of the plant is measured and the diameter at chest height (DAP) is taken of all the trees with DAP of 5 cm, or with a circumference greater than 15.7 cm/tree.
- Estimation of the biomass contained in the foliage at the soil surface, through random measurement of 1 m<sup>2</sup> calculated from the dry weight of foliage contained in this area of surface soil.

Estimation of carbon storage was carried out on 11 agroforestry plots where 12 species of native trees were found, including logging and firewood species. In general, women farmers were receptive to the use of the methodology, especially for the collection of field data, but there were some weaknesses in carrying out the calculations required for the estimation, since many of the women do not have the literacy or numeracy skills required to perform the work. Assistance from FIPAH in measuring soil carbon sequestration was therefore required. In order to accomplish this, FIPAH provided training to youths between 16-18 years in basic methods for data collection and surveying required for estimating above and below ground carbon storage. No data was available at the time of this publication to report on the findings from the biomass carbon storage.

The evaluation found that there are significant hurdles to accurately measuring and evaluating soil carbon stock changes particular with the rigor necessary to tie into voluntary and compulsory carbon markets. While training farmers in data collection and monitoring is laudable, this may be a task better performed by trained experts since many farmers reported difficulty in taking measurements and performing calculations necessary to establish robust measurements of carbon sequestration. A further difficulty was the timeframe of the project was insufficient to establish gains in soil and biomass carbon stocks. A large body of research shows that changes in soil and carbon stocks often take several years to decades to take place (e.g., Powlson, Whitmore, and Goulding, 2011). Thus, the timeline of the project was not extensive enough to find significant changes. This points to the need

for more continuous and long-term funding by donors and institutions.



***Young women and men were trained in data collection for analyzing carbon sequestration. Involving youth, as one CIAL explained, was critical to transferring knowledge to the next generation and to keeping the CIALs relevant and youthful. (Photos: Ryan Hottle)***



## 4. Project outcome evaluation

Overall the project was highly successful for a number of important reasons, but not without room for improvement. An unofficial measure of the project's success was how many women farmers outside of the project were interested in joining after they viewed the progress being made by women farmers involved in the project. FIPAH reported that, "They have expressed their enthusiasm for the potential to improve their income and produce more food for their families, and in improving the quality of life, especially of their health, through the use of improved stoves and the incorporation of new practices. Other women have shown an interest in participating as a result of learning about the experience that the women participants have had with the project."

We attribute the success of the project to how well it (1) incorporated traditional and indigenous knowledge systems particularly in the design and implementation of agroforestry systems, (2) engaged men, which led to "slow, organic changes" within FIPAH and the CIALs as men extended more recognition, respect, and support of women-led initiatives, (3) used rigorous needs assessment and participatory action research design (i.e. stakeholder engagement) throughout the duration of the project, with CIALs taking the lead on major aspects of the project, (4) incorporation of best management practices including modern scientific understanding, (5) targeted gender equity project outcomes specifically through targeting land tenure for women and reducing drudgery associated with fuel wood collection and exposure to indoor air pollutants, (6) used accurate and reliable indicators standardized across projects to assess impacts especially for economic changes, gender outcomes and greenhouse gas and carbon storage, and (7) took advantage of farmer-led data collection experimentation.

A key strength of the project was that it will continue to provide benefits for a significant period of time after the project is concluded. While the cookstoves provided an immediate tangible benefit, the agroforestry and coffee plantings will continue to provide increases in production, income, nutrition, and food security for the women involved in the project and their households. Male farmers reported being more open to accepting the control and sharing of land, resources, and household income with women. Facilitating women leaders to drive the changes themselves and engaging men farmers from the start enabled change to arise largely from within FIPAH and the CIALs in an organic manner that has facilitated sustainable impacts

The project was not without room for improvement: specifically, the farmer's knowledge of farmer-led crop breeding and research could have been harnessed to test a wide variety of coffee varieties under different conditions, using soil fertility amendments for example. The use of only two varieties

of coffee could cause greater vulnerability in the future. Likewise, the selection of agroforestry species seemed, at times, not to reflect the needs or wants of farmers; and some selections seemed inappropriate for the growing conditions. Better data collection systems that use text-based data entry could allow for easier data transfer, aggregation, analysis and sharing. This, in turn, would allow for better data quality and quantity, and could increase the ability to share research based on these studies.

These limitations, which likely resulted from the limited amount of time to design and implement the project, are undoubtedly outweighed by the many successes of the project. Providing women with access to land and control over labor, resources, and income is an innovative and straightforward approach to increasing gender equity while promoting a more resilient and sustainable agricultural system. The impacts and next stages of this project should be followed to better understand the continued impacts, successes and lessons learned.

### **Strengths**

1. **Long-lasting income generation potential** for women and farming households. Because coffee and other agroforestry crops can remain productive for decades, there are likely to be lasting economic benefits that appreciate over time.
2. **Local farmer organizations (CIALs)** have a history and continued openness to innovation and research. The presence of the CIALs provided a strong foundation for the project and enabled a well-developed participatory approach.
3. **Clear and strong gender equity impact** that will likely continue. FIPAH reported that, “The Yorito CIAL has incorporated a gender committee to strengthen the development of capacities and financial resources for women organized in the CIALs of the region. The goal is to improve their access to financing and to support access to the means of production for women of the region organized in CIALs.”
4. **Direct focus on needs** of community and women farmers rendered the project highly relevant, and women farmers had a strong reason to participate and stay involved.
5. **Specific targeted approach** directly improved livelihoods for both women and men farmers.
6. **Established groundwork for carbon sequestration valuation.** CIALs are well positioned for potential future carbon sequestration payments, through voluntary offsets or otherwise.
7. **Modelling of sustainable practices** provided examples for larger farming community. Agroforestry and shade-grown coffee could become standard practice in the area over time.

## Weaknesses

1. **Limited selection of species for agroforestry plantings.** Nearly all of the women planted similar, if not identical, tree species. Some tree species appeared particularly ill-suited to growing conditions (particularly citrus varieties and peach); in some cases there were relatively high mortality rates.<sup>4</sup> The project appeared to only use two strains of coffee, both CLR-resistant. This is risky in the long-term to farmers, as CLR is not the only disease that can significantly impact productivity and yields. For example, *Ojo de Gallo* (*Mycena citricolor* fungus) and the coffee berry borer beetle (*Hypothenemus hampei*) are also potentially harmful, and CLR-resistant varieties are not more resistant to them. Many farmers are replanting the Lempira variety almost exclusively because of its high yields and natural CLR-resistance. This effectively reduces the coffee gene pool and makes further outbreaks of mutated CLR-resistant varieties more likely. CLR-resistant varieties may lose their resistance over time, as was documented with the “Kent” strain in India, where there was a near complete loss of resistance over a 10-year period. Loss of CLR resistance was also documented in some varieties of *C. iberica* and *C. canephora*. The monoculture use of Lempira across Honduras is a significant risk, and it could prove to be a significant but preventable error in decades to follow.
2. **No experimentation design for planting.** The farmers would have been capable of doing an experimental design for planting, but there was no system for collecting data on the effectiveness of new plantings over time.
3. **Significant trade-off for quality.** CLR-resistance is generally created when Arabica and Robusta coffee varieties are crossed. While Robusta is not considered to be a high quality variety, it does exhibit good CLR-resistance. Thus, the CLR-resistant varieties are generally considered to be of inferior quality to pure Arabica varieties.<sup>5</sup>

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<sup>4</sup> Ants appeared to be a major cause of defoliation among the citrus, and a strategy for controlling ants may be necessary. On the other hand, simply planting more regionally appropriate species may be the best course of action.

<sup>5</sup> Robusta (coffea Canephora), typically produced at lower altitudes, is more disease- and pest-resistant (partly because of its higher caffeine content), and typically produces a larger crop than Arabica. It is usually much cheaper. In 2014, the future market for Robusta is \$0.70 per pound, while Arabica is \$1.14 per pound. Actual delivery prices for both species range from much lower for the lowest grades of Robusta to more than \$10.00 per pound for small lots of Arabica. Good horticultural practices and dedicated growers could produce better quality Robusta, but it is unlikely to compare favorably to good Arabica.

## Threats

1. **New strains of pests or pathogens** could negatively impact coffee plantings. This may be especially true where large-scale monocultures of single coffee varieties (i.e. Lempira) have been replanted. Honduras as a whole is at risk due to over-reliance on this single coffee variety.
2. **Lack of maintenance of stoves or improper use** could reduce efficiency, eliminate health benefits, or lead to discontinued use among households. While this is a threat, it did not appear to be immediately likely, as many farmers seemed to improve construction techniques and maintenance over time.
3. **Lack of carbon pricing or inability to tap into financial incentives for carbon sequestration** may reduce incentives for farmers to engage in practices that increase above- and below-ground carbon sequestration.
4. **Usurping of land, income, or decision-making by male farmers** (e.g. husbands, brothers, other land owners, etc.) from women farmers, which could reverse gender equity gains. Ensuring that women receive income from project-based technologies is an important consideration.

**Figure 7: Summary of strengths, weaknesses, opportunities, and threats (SWOT) analysis**

<p><b>S</b> <b>Strengths</b></p> <ul style="list-style-type: none"> <li>Project team with extensive experience of working with farmer groups</li> <li>CIAL farmer groups with history of participatory action research and farmer-led seed breeding</li> <li>Tight focus on specific needs of farmers</li> <li>Provided long-lasting benefits for women and land tenure</li> <li>Extensive data collection</li> </ul>	<p><b>W</b> <b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>Lack of genetic diversity in coffee plantings</li> <li>More appropriate agroforestry tree crops</li> <li>Lack of data on fuel wood usage with and without improved stoves</li> <li>Lack of ongoing data collection on mortality and yield of crops planted</li> </ul>
<p><b>O</b> <b>Opportunities</b></p> <ul style="list-style-type: none"> <li>Increased role for farmer-led experimentation</li> <li>Diversification of coffee and agroforestry species</li> <li>Use of mobile telecommunications-based data collection</li> <li>Soil testing analysis using correlated colormetric approach</li> </ul>	<p><b>T</b> <b>Threats</b></p> <ul style="list-style-type: none"> <li>Usurping of land or financial benefits of project by men</li> <li>Mutation of coffee leaf rust or introduction of other pest-pathogens</li> <li>Lack of water availability from increasing demand from large scale coffee plantations</li> </ul>



#### 4.1. Increased access to and control over land by women

Many women reported having little participation in growing crops beyond home gardens or were only involved in particular processes of production such as weeding, harvesting, winnowing, etc., but not decision-making about agriculture. Having control over land and production was novel to most, if not all, of the women farmers involved in the project. One farmer reported that having control over a small plot provided greater control not only over agricultural production but also over money and the use of household income. Access to land seemed to offer a large leverage point for the empowerment of women at a greater level, which also elevated women's status in their communities. At the same time, men have become increasingly supportive of women's role in such experiments. Many see benefits to the family as a whole in reducing demand for firewood and increasing the cooking quality of stoves. Men also see value in diversifying their farm production with fruit and coffee trees, and of supplying their families with wood for fuel and small building projects.

There are also social benefits noted by the women and men belonging to CIALs. Learning to experiment together and to solve problems socially has increased confidence among members. This translates into an ability to address other problems that threaten local lives and livelihoods, including land grabs and threats of violence. This should make further technical innovation more likely. The work FIPAH is doing with the targeted CIALs strengthens social and technical capacities in a way that recognizes the interaction between the two domains of human experience.

As a result of the experience of the PROLINNOVA project, the ASOCIAL Yorito has incorporated a gender committee to strengthen the development of capacities and financial resources for women organized in the CIALs of the region, with the goal of improving their access to financing and to support access to the means of production for women of the region organized in CIALs.

#### 4.2. Addressing needs

About 35% of the participants in the project have more than five years' membership in a CIAL, the remaining 65% have at least two years organized in the CIAL. Members enjoy the improved sense of confidence that comes from learning new technical skills and appreciate the social solidarity that comes from solving problems together. These skills become resources when new experiments are introduced into FIPAH's network.

FIPAH's work encouraged a slow, organic change in gender relations, with increasing decision-making authority and access to resources for women. Specifically:

- 51% of the women report that the husband participated in all the activities including establishment and management of the agroforestry plot, while 30% report that the husband participated in at

least 3 activities and 16% report that the husband had no role in the establishment and management of the agroforestry plot.

- 51% of the women consider that they control the plot, either because it was ceded to them by the husband or because it is their property. 16% consider that the control of the plot is shared by them both, and 33% consider that the husband continues to control the plot.

It is apparent that the experiments are designed to meet multiple local needs, including an array of direct consumption and income-generating needs. Specifically:

- 42.5% of the women participating in the project report that they participated in all activities of their farm plot, including design, establishment, management, and monitoring of the plot. These women also expect to benefit from their labors as a family. Thus far, there appear to be few problems with men taking over the benefits of the agroforestry systems and the carbon sequestration – should the latter benefits materialize – but this is a subject to continue monitoring.
- 100% of the participants report that one of the criteria of selection of the fruit species included good adaptive capacity to the locality, family consumption, or sales.
- At least 52% of the women interviewed considered one of the selection criteria of the logging species to be the value of the wood, the rest of the group considered diverse selection criteria. It is important to mention that 27% of the plots established already had forestry species inside the plots.
- 82% of the women interviewed reported that the principal criteria for the selection of condiment species was for domestic use (medicinal and food use), and the 18% remaining selected the condiment species with an eye to sales.
- 77.5% of the women participants considered that one of the selection criteria for firewood species in their plots was either its use as shade in the agroforestry system or for domestic firewood.

### **4.3. Income for women**

Direct income provision for women was one of the strongest potential impacts of the project. Notably, economic gains are likely to: 1) increase over time as the plantings mature and 2) endure for a long period of time (typically coffee plants take 3-5 years to bear fruit and can last for 40 to 50 years of good production).

### **4.4. Women's capacity to manage household budgets**

Women farmers report having greater understanding of and control over household budgets, the costs of production, and the potential for income generation as a consequence of their participation in the CIAL. This knowledge and control, the women farmers reported, was likely to grow with the project and with their participation in the CIAL.



Asked whether they expected to keep control over their incomes, some women said that they would be in charge of the incomes, while others stated that it would be used much like the rest of the income that the household receives, and joint decisions would be made about spending and saving.

Some women reported that they were more likely to spend the money on expenditures to benefit the whole family (improvements to house, books and school uniforms for children, etc.), whereas men may be more tempted to spend it on items for themselves (e.g. a motorcycle). Thus, some women reported that the whole household was likely to benefit if women were given greater control over household financial resources.

#### **4.5. Youth training**

Youth training of 16-18-year-old women and men in the basic science of carbon sequestration and surveying (collection of above- and below-ground carbon sequestration data) built ownership and capacity within the CIALs. Involvement of youth, one CIAL explained, is critical to extending the progress made by the CIALs to the next generation. In one community, the CIALs organized a youth CIAL that was explicitly created to foster youth leadership and innovation.

Involvement of youth, one CIAL explained, is critical to extending the progress made by the CIALs to the next generation. In one community, the CIALs organized a youth CIAL that was explicitly created to foster youth leadership and innovation. Many facilitators at the bi-annual conferences held by the CIALs were facilitated and led by young professionals. Such involvement is likely to provide a bridge to future generations and keep the organization diverse in terms of age and experience, allowing it to maintain relevance even while many young people attempt to find jobs outside of farming.

## 5. Recommendations

While the overall project was evaluated as a success and indeed a model for other projects, the project was not without room for improvement or lessons learned. Specifically, the farmer's knowledge of farmer-led crop breeding and research could have been harnessed to test a wide variety of coffee varieties under different conditions, using soil fertility amendments for example. The use of only two varieties of coffee could cause greater vulnerability in the future. Likewise, the selection of agroforestry species seemed, at times, not to reflect the needs or wants of farmers; and some selections seemed inappropriate for the growing conditions. Better data collection systems that use text-based data entry could allow for easier data transfer, aggregation, analysis and sharing. This, in turn, would allow for better data quality and quantity, and could increase the ability to share research based on these studies.

These limitations, which likely resulted from the limited amount of time to design and implement the project, are undoubtedly outweighed by the many successes of the project. Providing women with access to land and control over labor, resources, and income is an innovative and straightforward approach to increasing gender equity while promoting a more resilient and sustainable agricultural system. The impacts and next stages of this project should be followed to better understand the continued impacts, successes and lessons learned.

The following are a set of recommendations that we offer—not as a list of “what should have been done”—as novel ideas and concepts that could be incorporated into ongoing and future projects.

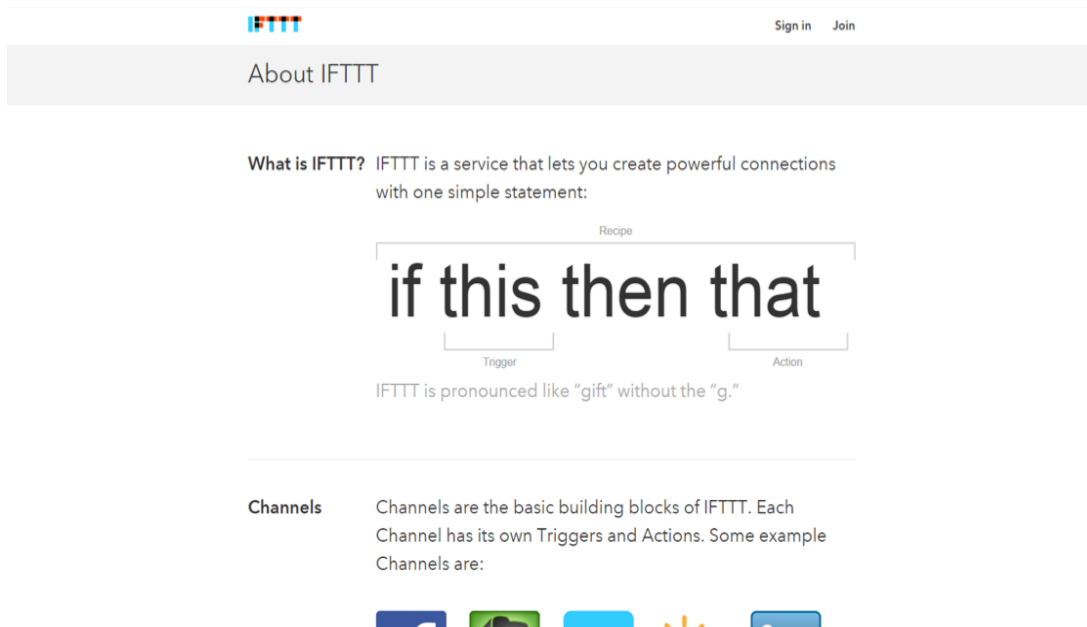
**Farmer-led data collection and experimentation:** Farmer-led experimentation is a superb means of generating useful data and explicitly involving farmers in the project, such that the project becomes more meaningful and tangible to them. When combined with participatory action research this can facilitate greater involvement and ownership of women and men farmers in the project.

The most significant limitations to farmer-led experimentation is ensuring quality data collection methods are used and that data gathering is feasible at the project and program level. The use of mobile telecommunications has considerable potential to help address the second limitation of farmer-led experimentation, whereas the first limitation still requires good training and consistent monitoring and when necessary facilitation by the project team.

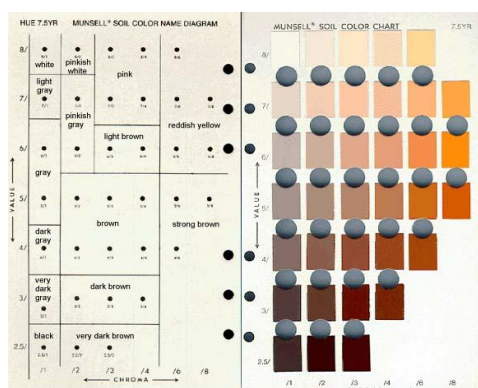
Use of real-time, internet-based database management allows farmer-scientists to feed data directly into shared accounts and can instantly provide statistical analyses of data. While the vast majority of farmers do not have access to computers or smart-phones, many do have cellular phones with texting capability that would allow data to be automatically transferred to Google Docs spreadsheets for

analysis. “If this then that” at IFTTT.org provides a free service which has this capability. This could be a game changer in terms of data gathering and reporting, particularly by projects that rely on farmers without direct access to computers but who do have access to cell phones.

**Figure 8: SMS text-based data entry could prove to be a “game-changer” for the collection of data for participatory farmer-led research, for example If This Then That at [www.ifttt.org](http://www.ifttt.org) allows users to log data directly from texts to programs such as spreadsheets within Google Docs.**



Munsell color charts can provide a means of (1) rapidly measuring soil color which may be able to assist in classification of soils and, in some situations, indication of carbon accrual in soils when soil hue and carbon content can be well correlated and (2) assessing plant nitrogen uptake which could help inform farmers about fertility needs of plants. Such colormetric data analyses offer assessment strategies that farmers can easily understand and utilize without expert assistance or expensive soil/plant tissue analyses.



**Baseline and milestone surveys:** Through similar approaches farmers could also be prompted to answer key research questions pertaining to their needs, project outcomes, and other important pieces of data which could further the likelihood of project success. Examples of questions that could be asked include:

- a. What is the most important need for your household or farm?
- b. What is the most important need for your community?
- c. What innovations would you like to test on your farm?
- d. What innovations would you like to test in your community?
- e. How many hours/days did it take to plant the agroforestry plot?
- f. How much maintenance is required to maintain plots? (How much time weeding, fertilizer/fungicide application, harvesting, etc.?)
- g. What is the total yield from crops? (Yield for particular coffee varieties? Yield for particular agroforestry crops?)
- h. Yield data: total yield, days to flowering, days to maturity etc.
- i. Soil: color, texture (which could be correlated with more rigorous soil tests that have already been taken in order to lower costs but still arrive at useful conclusions)
- j. Meteorological data: rainfall (gauges), temperature etc.
- k. Disease Prevalence: extent of CLR prevalent, photos from phone of pests
- l. Plant nutrition: tissue color, root nodulation
- m. Plant desirability: color, taste, ease of preparation, etc.
- n. Geographical data: elevation, soil type, etc.
- o. Carbon sequestration data: tree mass (diameter at breast height, estimated height), leaf litter, soil carbon data, etc.
- p. Cook stoves: fuel wood use without improved cookstove, fuel wood use with improved cookstove

**More explicit publication strategy:** It should be possible to generate at least three to five peer-reviewed publications for an extended multi-country project of this nature. This will require a more planned approach, however, and one in which project teams are more explicitly involved in the writing process throughout the project from the beginning stage through final analysis.

**In-country literature review on food security, gender and climate:** Each project team, in conjunction with the program team, could conduct literature reviews of food security, gender, climate change impacts, and past projects that have attempted to address these issues prior to project implementation or as part of the application process. This would (a) provide a solid means of

assessing the knowledge and rigor of potential project teams, (b) create a learning environment for both the project team and program team to more fundamentally understand and assess current contexts, future challenges, and successes and failures of projects that have been implemented in the past. This would also assist in developing a strong project design, and the outcome could generate a publishable paper for each project team, increasing their motivation.

**Baseline needs assessment and survey of specific communities and households:** Prior to project design, project teams could be tasked with conducting a thorough needs assessment in the villages and households with which they plan to work. This could consist largely of the survey methodology described above. While the results of the needs assessment would probably not be able to be directly published, making this phase a separate deliverable would increase project team compliance. Limitations, omissions, and miscalculations of the survey methodology could also be identified by the project team and the methodology could be corrected.

**Post-implementation survey:** A period of time after project implementation is completed, a follow-up survey on both farmers involved and not involved in the project could be conducted to assess project impacts. Results of the pre- and post-implementation survey could be used to generate a publication, in addition to the more empirical data gathering strategies.

**Empirical data-gathering strategies:** Data gathered through more empirical “physical science” approaches, such as yield and plant characteristics (disease resistance, time to flowering, height, leaf area index, etc.), soil analyses, carbon sequestration, could be used to generate a research paper either for each individual project or for all three projects as a whole. Standardization of methodologies (described above) would be extremely helpful if cross-comparison is desired.

**Seek greater genetic diversity of coffee varieties:** For example, a farmer may plant 3-5 different types of coffee using randomized block design and then report on yield, disease resistance, time to fruiting, and other key parameters of the various varieties. This would be useful in choosing future plantings, depending on soil type and elevation. More diverse plantings may also hedge against future pest or disease outbreaks. The Central Coffee Research Institute in Balehonnur India has developed multiple CLR-resistant strains (e.g. Sln 5-A, Sln 5-B, Sln 6, Sln 9, Changraka) that may be worth testing alongside Lempira and IHCAFE-90. The Costa Rican Coffee Institute (ICAFFE) has also developed a CLR-resistant variety called Obata that is reported to have a similar quality to 100% Arabica varieties, while providing predictable and homogenous yields.

**Capture and re-use coffee-based by-products:** According to one estimate, the average European cup of coffee or espresso (125 ml) requires 140 liters of water – a ratio of coffee to water of 1 to 11,000. Capture and re-use of coffee-processing organic matter (such as cherries) and wastewater may

play an important role in reducing water shortages, decreasing loading of streams with organic matter, and improving soils. Processing alternatives to the “wet process” such as the “semi-wet process” and “dry process” may also be considered for reducing water use.

**Further test rock dusts for needed soil nutrients:** Initial analyses of local rock dust showed high levels of phosphorus and calcium, two essential plant nutrients that were found to be at low levels in several of the sampled soils. Many farmers have already been experimenting with rock dusts, and several were discussing the potential of setting up microenterprises around the use of rock dust. Better testing, training, and equipment for processing rocks into rock dust is needed. For example, some farmers were trying to use metamorphic rocks containing high quantities of quartz (made up primarily of silicone crystals) as a source for rock dust. Such rocks were unlikely to have many available plant nutrients, whereas rock dust made from volcanic rocks is more likely to have the needed nutrients. Simple trainings could help farmers identify which rocks are most likely to be beneficial for crops.

**Provide training on planting techniques, especially for women and youth:** While many women managed successful plantings, it was evident that most male farmers were more experienced. Strategies for increasing planting success include: early stage cover-cropping (e.g. cow pea, velvet bean, and runner bean, as well as other leguminous crops, particularly those with high nitrogen fixation potential), bean intercropping (as was done in many locations), greater use of woody nitrogen fixers (higher density plantings with intention of 90% removal for fuel wood and other purposes), and the use of swales (described below) and micro-catchments.<sup>6</sup> Intercropping and cover cropping can reduce soil erosion and increase plant available nitrogen—two critically important outcomes for small-scale farmers in Honduras who are farming on steep slopes and on nitrogen deficient soils.

**Engage in community work:** Many women farmers reported difficulty planting, particularly when they did not have assistance. “Barn-raising” style plantings, where the larger community or CIAL is involved in the process of transplanting coffee and agroforestry saplings, may accomplish a lot of work in a short period of time as well as increase farmer-to-farmer innovation. More experienced farmers can share planting techniques, fertilizer recommendations, etc. during the critical time of planting, leading to an increase in transplanting survival and, later, yields.

**Incorporate home gardens:** Integrating home gardens into agroforestry projects may help spur greater interest among women farmers. It was evident that household gardens were well tended by many women and throughout the visit women farmers were observed consistently collecting seeds and other germplasm from plants in household gardens that they found useful, beautiful or interesting as they travelled from house to house. Home gardens can provide important sources of nutrition,

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<sup>6</sup> Micro-catchments are small depressions in which water is collected in order to increase infiltration and reduce runoff.

aesthetic beauty, sense of place, and habitat for biodiversity, especially pollinators. Importantly, home gardens may also help the project gain increased interest in the agroforestry portion of the project by women farmers.

**Build capacity in integrated pest management of CLR and other coffee pests and pathogens during workshops and training exercises:** For an example of a list of measurements to take in order to ensure adequate pest management, see appendix 4.

**Further farmer-led experimentation:** The project was successful in equipping farmers to conduct research on farms, but the scope of the experimentation could expand. A participatory action research approach generally advocates that farmers should not only participate in the research but also should help decide the experiment. An example of a potential is in the appendix.

**Explore “organic,” “fair trade,” and “carbon negative” certification of coffee and other farm products:** The CIALs provide an ideal model and vehicle for certification programs that could be facilitated by FIPAH or other organizations. This would increase farmers’ access to higher value markets.

**Include micro-financing and lending circles:** With facilitation by CIALs or FIPAH, micro-finance could increase access to improved cookstoves, CLR-resistant coffee plants and other innovations valued by farmers but too expensive for them to purchase outright.

**Increase focus on water, especially water catchment and storage at the household level for household consumption and potentially small-scale irrigation:** Nearly every CIAL identified water quantity and quality as a principal challenge. Experimentation could be done on a wide variety of water catchment systems, including ICB totes and above- and below-ground ferro-cement tanks. Most CIALs reported that they relied upon a single large water tank for an entire community. Water from local streams, causes a high risk of contamination, particularly in downstream communities. Additionally, if the community tank were to run out or if it becomes contaminated, there is very little redundancy in the system for people to find alternative water sources. Household tanks (or at least neighboring houses) that collect rainwater from roofs of houses, solar dryers and other structures would increase the number of tanks, thereby mitigating the threat of contamination or shortages, while decreasing the amount of time spent collecting water, a task assigned to women.

**Support micro-catchment and terraforming projects to decrease flooding and soil erosion:** Ditches on contour with elevation (otherwise known as “swales”) could be a critical tool for reducing erosional losses, providing better access points on steep slopes, preventing runoff, and encouraging water infiltration. Various water harvesting earthworks could be seen in many locations, but they were

not extensive and lacked appropriate design. Many women were working on nearly 45-degree slopes, causing difficulties in planting, pruning, weeding and harvesting. Swales decrease difficulty and aggravation while maximizing environmental and agronomic benefits.

However, creating extensive micro-catchment systems often involves a lot of difficult and time consuming labor, a particular obstacle for some women farmers. The aforementioned community work, or “barn-raising style plantings” could be a novel way of creating an extensive micro-catchment system on a plot or farm. Excellent Development, a United Kingdom-based non-governmental organization that works in Kenya, has used “barn-raising” to implement large-scale implementation of swales at community levels for the past two decades.

**Improve cooking efficiency through complimentary strategies:** Selection and drying of fuel wood and proper maintenance of cookstoves, although often overlooked, provide important low-cost strategies that can simultaneously lower health risks and increase cooking efficiency.



## 6. Conclusion

Overall the project was viewed to be highly successful. An unofficial measure of its success was how many women farmers were interested in joining in on the project after they viewed the progress made by women farmers involved in the project. A key strength of the project was that the changes in gender relations have developed endogenously within key social structures affecting project outcomes. The project will continue to provide benefits for a significant period of time even after the project is concluded. As the coffee plantings mature and as the agroforestry trees continue to grow and bear fruit, the income generation of the women involved, and their households, will continue to benefit.

We attribute the success of the project to how well the project (1) incorporated traditional and indigenous knowledge systems, (2) engaged men, which led to "slow, organic changes" within FIPAH and the CIALs as men extended more recognition, respect, and support of women-led initiatives, (3) used rigorous needs assessment and participatory action research design (i.e. stakeholder engagement), (4) incorporated best management practices including modern scientific understanding, (5) targeted gender equity project outcomes, (6) used accurate and reliable indicators standardized across projects to assess impacts especially for economic impacts, gender outcomes and greenhouse gas and carbon storage, and (7) took advantage of farmer-led data collection experimentation.

The improved cookstoves and agroforestry project administered by FIPAH and the participating CIALs provides a model low-emissions, climate resilient and gender transformative project. The needs of both women and men farmers were extremely well addressed, evidenced by the fact that many farmers asked to be part of the project. The practices were sustainable and likely to lead to increased resilience of rural households to climate impacts. The benefits will likely be significant and sustainable, as the coffee and agroforestry systems mature. Key factors for the success of the project were: the experience of farmers with innovation and participatory research; engagement of men that enabled organic changes in gender relations in local organizations and households; the strong history, knowledge and working relations of FIPAH with farmers on the ground; and an extremely well designed and executed project that took into account the needs of farmers.

## Appendix 1: CIAL annual conference, 2014

Since 2000 CIALs and FIPAH have focused on participatory breeding and seed-saving of red beans and maize. They meet every second year to share results from their breeding activities and other ongoing projects. Many organizations and government employees, particularly from the agricultural sector, attended and spoke during 2014 meetings, including the International Centre for Tropical Agriculture (CIAT), Heifer International, and Honduran Ministry of Agriculture and Livestock.

CIALs are typically composed of 10 to 30 members representing both genders, though the gender balance is sometimes lopsided. They attract the innovators within their community. Most CIAL members were smallholder farmers. CIAL members explain that wealthier farmers and plantation holders were not as interested or had less time for monthly meetings and other work required of a CIAL member. “Being in a CIAL is hard work,” Sally Humphries, Director of FIPAH, explained. An important function of the CIAL is that it provides a “safe place” for less conventional smallholders to share innovations and experiences and tap into opportunities such as lending groups and organizationally funded projects.

At the 2014 conference, most farmers reported on the yields of different improved (hybridized) and landrace red bean varieties. Farmers analyzed variables, including rainfall, temperature, time to flowering, time to fruit, yield, and quality indicators such as appearance and taste. While some farmers seemed to be reviewing a rather tightly scripted presentation that was nearly identical to the other presentations given, farmers were indeed gathering to share data they had collected themselves in a scientific fashion. Gathering climatological data alone is a “citizen-science” activity that can deepen farmers’ understanding of weather and climate and sensitize them to ongoing changes.

While many organizations can be “silo-ed” in their particular areas, the conference provided a platform for mutual exchange and potential collaboration. Farmers appreciated the opportunity to travel and connect with peers. CIALs clearly contributed to the overall success of the project.

On the first day of the conference, a woman farmer gave a presentation of the agroforestry portion of the project to an audience of 60-70 farmers, about half men and half women. She explained the basic project goals, design, and early results to the audience. After she had finished, the first question posed to her was from another woman, who asked “How did you come up with this project? It is very unique in giving the women control.” After responding about the goals of the project, the same woman from the crowd said, “It is very inspiring. I would like to learn more about this project and to be involved myself.”

## Appendix 2: Changes in climate and climate change threats reported by farmers

- a) **More frequent heavy rains and hurricanes.** Rains during harvest season create difficulty harvesting crops and increase drying times. (As mentioned earlier, rains may also increase the likelihood of crop diseases, including CLR). Farmers were acutely aware of the possibility that climate change could increase the impact of hurricanes, having lived through Hurricane Mitch in 1998, which caused an estimated USD 660 million in economic damage. One farmer pointed out that heavier rains could also lead to more road cuts and bridge failures, temporarily suspending transportation and negatively impacting food security, medical assistance, and market access.
- b) **Higher temperatures** have meant that farmers living at higher elevations can grow crops that were previously difficult or impossible to grow. In some cases, this has been a boon. This project tried a variety of well-established (e.g. coffee, plantain, etc.) and rarely grown species (e.g. apples).
- c) **Large-scale soil erosion** is associated with heavy rainfall, as the farmers have observed. They explained that large-scale deforestation, particularly from large plantation farms, also caused much of the soil erosion they saw. Because the project explicitly financed and encouraged planting in agroforestry systems, extremely effective at slowing erosional losses, the project addressed this threat very solidly.
- d) **New rusts and other diseases** might result from climate change, one farmer astutely pointed out. Monoculture coffee plantations encourage the spread of disease (including CLR) and decrease the resilience of the farm household by increasing their risk. Monoculture plantations, which are becoming increasingly common, contribute to large-scale denudation of the landscape and further exacerbate disease, erosion, and loss of top soil.

## Appendix 3: Relevant integrated pest management practices

- Mulching: to reduce likelihood of bacterial infection by reducing rain-splash
- Foliar spraying: Compost teas or copper sulphate mixtures<sup>7</sup>
- Nutrient management: Crops with poor or unbalanced fertility may exhibit greater susceptibility to CLR and other diseases. Ensuing healthy planting could decrease the risk and spread of disease.
- Pruning and handling: Strategic pruning of coffee plants may reduce incidence of disease. Likewise, reducing contact with plants during wet periods can decrease the spread of disease.
- Systemic fungicides: Can be used where organic production is not being practiced
- Optimal shade: reduces “overbearing” of plants (high yields) which reduces likelihood of infection. Agroforestry plots can provide optimal shade.

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<sup>7</sup> Copper sulphate mixtures are made by dissolving one kilogram of copper sulfate in 5 liters of water in a permeable bag for 12 to 24 hours. This is then added to well dissolved mixture of 190 liters of water and 5 kilograms of lime.

## Appendix 4: Experiment with soil amendments

Following is an example of an experiment that could be conducted to study soil improvements with various soil fertilizers and amendments. The experiment could be laid out using a fairly simple block design pattern for field crops using the following materials:

- Ash
- Compost
- Volcanic rock powders
- Effluent from methane digesters
- Traditional and novel composts
- Harmone: traditional compost mix
- Hochatchi: organic fertilizer, cow manure
- Coffee pulp and waste water reclamation
- Biochar

Through similar approaches farmers could answer key research questions pertaining to their needs, project outcomes, and other important pieces of data that could improve food security and contribute to low emissions agriculture.

## Appendix 5: Additional data collection opportunities

### **Farmers could also collect the following agricultural data:**

- Yield data: total yield, days to flowering, days to maturity etc.
- Soil: color, texture (which could be correlated with more rigorous soil tests that have already been taken in order to lower costs but still arrive at useful conclusions)
- Meteorological data: rainfall (gauges), temperature etc.
- Disease prevalence: extent of CLR prevalent, evidence of disease and pests from photos from phone
- Plant nutrition: tissue color, root nodulation
- Plant desirability: color, taste, ease of preparation, etc.
- Geographical data: elevation, soil type, etc.
- Carbon sequestration data: tree mass (diameter at breast height, estimated height), leaf litter, soil carbon data, etc.
- Cookstoves: fuel wood use without improved cookstove, fuel wood use with improved cookstove

### **Participatory research surveying questions:**

- What is the most important need for your household or farm?
- What is the most important need for your community?
- What innovations would you like to test on your farm?
- What innovations would you like to test in your community?

### **Project specific questions which could be assessed on an annual or more frequent basis:**

- How many hours/days did it take to plant the agroforestry plot?
- How much maintenance is required to maintain plots? (How much time weeding, fertilizer/fungicide application, harvesting, etc.?)
- What is the total yield from crops? (Yield for particular coffee varieties? Yield for particular agroforestry crops?)

## Appendix 6: Metrics for analyzing project outcomes

A system for collecting and analyzing useful project data would assist the project greatly, including baselines, measurement of change, and outcomes. A monitoring and evaluation framework should be created for the project with indicators that inform the following questions.

- What was the cost of establishing the plots (capital and labor)?
- What are the annual incomes for women before and after the project?
- What is the survival rate of the various species and varieties of coffee and agroforestry species?
- How much additional labor is needed to weed, harvest, prune, etc.? Who in the household is principally in charge of this?
- What is the yield from the different species?
- How much are crops selling for?
- What percentages of crops are sold versus kept for household consumption?
- What is the prevalence of disease among the different coffee varieties?
- How much fuel wood was used before and after the project?

## Appendix 7: Agroforestry data

**Table 3: Plot size and species selected by women participants in agroforestry systems in the municipality of Victoria, Yoro, 2014**

Community	Farmer	Area in M <sup>2</sup>	Fruit Trees Established	Especies Condimentarias Establecidas	Especies establecidas	Maderables
La Fortuna	Aurora Figueroa	7000	Peach, Lemon, Mandarin, Orange.	Allspice and Cinnamon	Spanish Cedar, Inga, Mahogany	
	Aida Izcano	3500	Avocados and Mandarins	Allspice and Cinnamon	Spanish Cedar, Inga, Mahogany	
	Cándida Cruz	3500	Avocados and Mandarins	Allspice and Cinnamon	Spanish Cedra, Inga, Mahogany	
	Santos Reyes Medina	3500	Orange, Mandarin, Lemon and Peach		Inga and Mahogany	
	Flora Cruz	3500	Avocado, Mandarin, Orange, Peach	Allspice and Cinnamon	Inga, Mahogany and Sp. Cedar	
	Celea Bustillo	3500	Avocado, Mandarin	Allspice	Inga	
El Plantel	Ana María Castro	3500	Avocado, Mandarin, Peach	Allspice and Cinnamon	Mahogany, Inga, Sp. Cedar	
	Marcia Zelaya	3500	Avocado, Mandarin, and Orange	Allspice and Cinnamon	Mahogany, Inga, Sp. Cedar	
	Virginia Cruz	3500	Orange, Mandarin, Lemon	Allspice	Inga	
	Guadalupe Velásquez	3500	Avocado, Mandarin, Lemon, Nance (Byrsonima crassifolia), Orange	Allspice and Cinnamon	Mahogany and Sp. Cedar	
	Neiva Rosaura	3500	Avocado, Orange, Lemon, Mandarin	Allspice and Cinnamon	Mahogany, Sp. Cedar	
Cafetales	Mauricia Velásquez	3500	Nance, Orange, Mandarin, Avocado	Allspice and Cinnamon	Mahogany, Inga, Sp. Cedar	
	Lorgia Castro	3500	Avocado		Inga	
La Laguna	María Félix Cruz	1750	Avocado, Orange and Lemon	Allspice and Cinnamon Canela y pimienta gorda	Mahogany, Inga, Sp. Cedar	
	Leonor Hernández	1750	Orange, Mandarin and Lemon.	Allspice and Cinnamon	Mahogany, Inga, Sp. Cedar	
	Eladia López	3500	Orange and Avocado	Allspice and Cinnamon Pimienta gorda y canela	Sp. Cedar and Mahogany	
El Urracal	Bacilia Cruz	3500	Avocado, Orange and Mandarin	Allspice and Cinnamon Canela y pimienta gorda	Mahogany, Inga, Sp. Cedar	
	Miriam Suyapa Fúnez	3500	Avocado, Orange, Nance, Apricot, Mandarin	Allspice and Cinnamon	Mahogany, Inga, Sp. Cedar	
	Ignacia Gutiérrez	3500	Avocado, Nance, Apricot, Orange, Mandarine,	Allspice and Cinnamon	Sp. Cedar and Mahogany	
Guachipilín	Lidia Rosa Palma	2500	Avocado, Mandarin, Orange	Allspice and Cinnamon	Mahogany, Inga, Sp. Cedar	
	Ana Velásquez	3500	Avocado, Mandarin, Orange	Allspice and Cinnamon	Mahogany, Sp. Cedar and Guachipilín (Diphysa robinoides)	
	Paz Figueroa	3500	Avocado, Orange and Mandarin	Allspice and Cinnamon	Mahogany and Sp. Cedar	
	Oneida Castro	3500	Avocado, Orange, Lemon, Mandarin, Nance	Allspice and Cinnamon	Mahogany, Sp. Cedar, Guachipilín and Laurel (Cordia alliodora).	
	Yesenia Murillo	2000	Avocado, Mandarin, Orange	Allspice and Cinnamon	Mahogany and Sp. Cedar.	



**Table 4: Plot size and species selected by women participants in agroforestry systems in the municipality of Sulaco, Yoro, 2014**

Community	Farmer	Area in M <sup>2</sup>	Fruit Species Established	Condiment Established	Species	Logging Established	Species
Higuerito 2	Santos Hernández	3500	Avocado, Mandarin, Orange and Peach	Allspice and Cinnamon		Mahogany, Spanish Cedar	Inga,
	Sebastiana Gutiérrez	3500	Avocado, Mandarin, Orange	Allspice and Cinnamon		Mahogany, Spanish Cedar	Inga,
	Melida González	3500	Avocado, Mandarin, Orange	Allspice and Cinnamon		Mahogany, Spanish Cedar	Inga,
Monte Galán	Blanca Gutiérrez	3500	Avocado and Orange	Allspice and Cinnamon		Mahogany, Spanish Cedar	Inga,
	Blanca Hernández	3500	Avocado and Orange	Allspice and Cinnamon		Mahogany, Spanish Cedar	Inga,
San Antonio	Hilda Mencia	3500	Avocado, Mandarin, Orange	Allspice and Cinnamon			Inga
El Desmonte	Lucía Orellana	3500	Avocado, Mandarin, Orange	Allspice and Cinnamon			Inga, Spanish Cedar
Rio Arriba	Lidia Cruz	3500	Avocado, Mandarin, Orange	Allspice and Cinnamon			Inga, Spanish Cedar

**Table 5: Plot size and species selected by women participants in agroforestry systems in the municipality of Yorito, Yoro, 2014**

Community	Farmer	Area in M <sup>2</sup>	Fruit Species Established	Condiment Established	Sspecies	Logging Established	Species
La Patastera	Hilda González	3500	Peach, Orange, Mandarin, Avocado	Allspice and cinnamon		Mahogany, Spanish Cedar	Inga,
	Arcadia Hernández	3500	Avocado, Peach, Orange, Mandarin	Allspice and cinnamon		Mahogany, Spanish Cedar	Inga,
El Plantel	Cruz Gutiérrez	3500	Avocado, Peach, Orange, Nance, Mandarin	Allspice and cinnamon		Mahogany, Spanish Cedar	Inga,
	Dominga Pérez	3500	Avocado, Peach, Orange, Nance, Mandarin	Allspice and cinnamon		C Mahogany, Spanish Cedar	Inga,
	María Pérez	3500	Avocado, Peach, Orange, Mandarin	Allspice and cinnamon		Mahogany, Spanish Cedar	Inga,
Higüero Quemado	Gregoria Murillo	1750	Avocado, Mandarin, Apricot, Orange.	Cinnamon		Mahogany, Spanish Cedar	Inga,
Los Higüeros	Claudia Pérez	3500	Avocado, Peach, Apricot, Mandarin, Orange	Allspice and cinnamon		Mahogany, Spanish Cedar	Inga,
	Jova Pérez	2000	Avocado, Mandarin	Cinnamon		Mahogany, Spanish Cedar	Inga,
	Rosa Pérez	1750	Avocado, Mandarin, Orange	Cinnamon		Mahogany, Spanish Cedar	Inga,
La Esperanza	Ramona Medina	2000	Nance, Mandarin, Apricot, Orange	Allspice and cinnamon		Mahogany and Spanish Cedar	
	Ercilia Murillo	3500	Avocado, Mandarin, Orange	Allspice and cinnamon		Mahogany and Spanish Cedar	
	Bennis Castro	3500	Avocado, Mandarin, Peach, Orange	Allspice and cinnamon		Mahogany, Spanish Cedar	Inga,
	Yolanda Murillo	3500	Avocado, Mandarin, Orange	Allspice and cinnamon		Mahogany, Spanish Cedar	Inga,
Santa Cruz	Simeona Pérez	3500	Avocado, Mandarin, Orange	Allspice and cinnamon		Mahogany, Spanish Cedar	Inga,
Buenos Aires	Margarita Mejía	3500	Avocado, Orange, Mandarin, Peach	Allspice and cinnamon		Mahogany Caoba	
	Marleny Mejía	3500	Avocado, Mandarin, Peach, Apricot	Cinnamon		Spanish Cedar and Mahogany	
	Agustina Corea	1750	Avocado, Orange, Mandarin	Allspice and cinnamon		Spanish Cedar cedro	

## Appendix 8: Site and farmer data

**Table 6: Site and farmer data**

Municipality	Community	Plot Elevation MASL	Experimenters
Yorito	La Esperanza	1000-1300	4
	Los Higüeros	1250 -1400	3
	El Plantel	1500-1650	3
	La Patastera	1450 - 1500	2
	Santa Cruz	1350	1
	Higüero Quemado	1620	1
Sulaco	Rio Arriba	1200	1
	San Antonio	1250	1
	El Desmonte	1270	1
	Monte Galán	1420	2
	Higuerito 2	1500-1550	3
	Buenos Aires	1420 -1500	3
Victoria	Guachipilín	920 -1100	5
	La Laguna	1200-1350	3
	Cafetales	890 - 1000	3
	El Plantel	950 - 980	5
	El Urracal	1200 -1250	3
	La Fortuna	1350 -1450	5
<b>TOTAL</b>	<b>18</b>		<b>49</b>

## Appendix 9: Soil analysis data

**Table 7: Results of soil analysis on farms in the municipality of Victoria, Yoro, 2014**

Community	Women Farmers	pH	g-Kg <sup>-1</sup>		Cmol <sub>c</sub> -Kg <sup>-1</sup>				% Soil Carbon
			OM Content	NT	P	K	Ca	Mg	
La Fortuna	Aurora Figueroa	4.9	50.0 <sup>A</sup>	2.53 <sup>A</sup>		0.12 <sup>D</sup>	10.67 <sup>A</sup>	0.76 <sup>M</sup>	1.45
	Aida Izcano	5.61	70.96 <sup>A</sup>	3.55 <sup>A</sup>		1.05 <sup>O</sup>	35.5 <sup>A</sup>	1.46 <sup>M</sup>	2.06
	Cándida Cruz	5.40	50.66 <sup>A</sup>	2.53 <sup>A</sup>		0.85 <sup>O</sup>	41.3 <sup>A</sup>	2.10 <sup>A</sup>	1.47
	Santos Reyes Medina	4.39	63.44 <sup>A</sup>	3.17 <sup>A</sup>		0.95 <sup>O</sup>	35.10 <sup>A</sup>	2.05 <sup>A</sup>	1.84
	Flora Cruz	6.4	48.4 <sup>M</sup>	2.42 <sup>M</sup>		261 <sup>A</sup>	2188 <sup>M</sup>	195 <sup>M</sup>	1.40
	Celea Bustillo	5.0	51.5 <sup>A</sup>	2.57 <sup>M</sup>	2 <sup>B</sup>	97 <sup>B</sup>	593 <sup>B</sup>	74 <sup>B</sup>	1.49
El Plantel	Ana Maria Castro	6.56	62.0 <sup>A</sup>	3.10 <sup>A</sup>		0.94 <sup>D</sup>	84.0 <sup>A</sup>	0.95 <sup>M</sup>	1.80
	Marcia Zelaya	7.38	72.2 <sup>A</sup>	3.61 <sup>M</sup>		386 <sup>A</sup>	10550 <sup>A</sup>	140 <sup>B</sup>	2.09
	Virginia Cruz	7.57	70.9 <sup>A</sup>	3.55 <sup>M</sup>	2 <sup>B</sup>	224	15690 <sup>A</sup>	103 <sup>B</sup>	2.06
	Guadalupe Velasquez	7.02	69.6 <sup>A</sup>	5.63 <sup>A</sup>	3 <sup>B</sup>	345 <sup>A</sup>	14340 <sup>A</sup>	197 <sup>M</sup>	2.02
	Neiba Cruz	6.4	47.5 <sup>M</sup>	2.37 <sup>M</sup>	1 <sup>B</sup>	293 <sup>A</sup>	29710 <sup>A</sup>	110 <sup>B</sup>	1.38
Cafetales	Miriam Rosales	6.2	48.7 <sup>M</sup>	2.43 <sup>M</sup>	1 <sup>B</sup>	140 <sup>M</sup>	13780 <sup>A</sup>	131 <sup>B</sup>	1.41
	Mauricia Velasquez	7.4	85.4 <sup>A</sup>	4.27 <sup>A</sup>	1 <sup>B</sup>	178 <sup>M</sup>	24810 <sup>A</sup>	325 <sup>A</sup>	2.48
	Lorgia Castro	6.8	90.3 <sup>A</sup>	4.51 <sup>A</sup>	4 <sup>B</sup>	128 <sup>M</sup>	6330 <sup>A</sup>	364 <sup>A</sup>	2.62
La Laguna	Maria Félix Cruz	7.19	44.9 <sup>M</sup>	2.24 <sup>M</sup>	1 <sup>B</sup>	323 <sup>A</sup>	21910 <sup>A</sup>	278 <sup>B</sup>	1.30
	Leonor Hernández	7.46	74.8 <sup>A</sup>	3.74 <sup>M</sup>	1 <sup>B</sup>	4 <sup>B</sup>	15680 <sup>A</sup>	190 <sup>M</sup>	2.17
	Eladia Lopez	7.32	95 <sup>A</sup>	9.75 <sup>A</sup>	3 <sup>B</sup>	522 <sup>A</sup>	18080 <sup>A</sup>	264 <sup>A</sup>	2.76
El Urracal	Bacilia Cruz	7.04	70.3 <sup>A</sup>	3.51	4	112	8170	264	2.04
	Miriam Suyapa Fúnez	6.92	157 <sup>A</sup>	7.87 <sup>A</sup>	16 <sup>M</sup>	347 <sup>A</sup>	14550 <sup>A</sup>	496 <sup>A</sup>	4.55
	Ignacia Gutierrez	6.57	138 <sup>A</sup>	6.9 <sup>A</sup>	3 <sup>B</sup>	256 <sup>A</sup>	6860 <sup>A</sup>	250 <sup>M</sup>	4.00
Guachipilín	Lidia Rosa Palma	6.98	74.8 <sup>A</sup>	3.74 <sup>M</sup>	2 <sup>B</sup>	138 <sup>M</sup>	6210 <sup>A</sup>	154 <sup>M</sup>	2.17
	Ana Velasquez	7.1	69 <sup>A</sup>	3.45 <sup>M</sup>	13 <sup>M</sup>	431 <sup>A</sup>	9030 <sup>A</sup>	274 <sup>A</sup>	2.00
	Paz Figueroa	7.7	85.4 <sup>A</sup>	4.27 <sup>A</sup>	1 <sup>B</sup>	317 <sup>A</sup>	26780 <sup>A</sup>	388 <sup>A</sup>	2.48
	Oneida Castro	6.8	50.9 <sup>A</sup>	2.64 <sup>M</sup>	1 <sup>B</sup>	155 <sup>M</sup>	5560 <sup>M</sup>	122 <sup>B</sup>	1.48

**Table 8: Results of soil analysis on farms in the municipality of Sulaco, Yoro, 2014**

Community	Women Farmers	pH	g-Kg <sup>-1</sup>		mg/kg <sup>-1</sup>				% Soil Carbon
			Contenido de MO	NT	P	K	Ca	Mg	
Higuerito 2	Melida Gonzales	6.59	83.3 <sup>A</sup>	4.16 <sup>A</sup>	1 <sup>B</sup>	361 <sup>A</sup>	9820 <sup>A</sup>	314 <sup>A</sup>	2.42
	Santos Hernández	6.26	83.3 <sup>A</sup>	4.16 <sup>A</sup>	1 <sup>B</sup>	462 <sup>A</sup>	9850 <sup>A</sup>	496 <sup>A</sup>	2.42
	Sebastiana Gutiérrez	6.98	74.8 <sup>A</sup>	3.74 <sup>M</sup>	1 <sup>B</sup>	350 <sup>A</sup>	5230 <sup>M</sup>	628 <sup>A</sup>	2.17
Monte Galan	Blanca Gutierrez	6.54	52 <sup>A</sup>	2.6 <sup>M</sup>	1 <sup>B</sup>	250 <sup>A</sup>	9340 <sup>A</sup>	335 <sup>A</sup>	1.51
	Blanca Hernandez	6.83	69 <sup>A</sup>	3.25 <sup>M</sup>	2 <sup>M</sup>	250 <sup>A</sup>	8550 <sup>A</sup>	315 <sup>A</sup>	2.00
San Antonio	Hilda Mencia	5.7	41.6 <sup>M</sup>	2.08 <sup>M</sup>	1 <sup>B</sup>	40 <sup>B</sup>	960 <sup>B</sup>	172 <sup>M</sup>	1.21
El Desmonte	Lucia Orellana	6.1	46.2 <sup>M</sup>	2.31 <sup>M</sup>	2 <sup>B</sup>	131 <sup>M</sup>	1559 <sup>M</sup>	548 <sup>A</sup>	1.34
Rio Arriba	Lidia Cruz	6.4	41 <sup>M</sup>	2.05 <sup>M</sup>	1 <sup>B</sup>	152 <sup>M</sup>	650 <sup>B</sup>	151 <sup>M</sup>	1.19

**Table 9: Results of soil analysis on farms in the municipality of Yorito, Yoro, 2014**

Community	Farmer	pH	g-Kg <sup>-1</sup>		mg/kg <sup>-1</sup>				% Soil Carbon
			OM Content	NT	P	K	Ca	Mg	
La Esperanza	Ramona Medina	6.5	53.5 <sup>A</sup>	2.68 <sup>M</sup>	1 <sup>B</sup>	189 <sup>M</sup>	4140 <sup>M</sup>	80 <sup>B</sup>	1.55
	Bennis Castro	7.8	61.7 <sup>A</sup>	3.09 <sup>M</sup>	7 <sup>B</sup>	869 <sup>A</sup>	12010 <sup>A</sup>	258 <sup>A</sup>	1.79
	Juana Ercilia Palma	7.4	46 <sup>M</sup>	2.3 <sup>M</sup>	1 <sup>B</sup>	207 <sup>M</sup>	12410 <sup>A</sup>	226 <sup>M</sup>	1.33
	Yolanda Murillo	7.3	54.9 <sup>A</sup>	2.74 <sup>M</sup>	1 <sup>B</sup>	170 <sup>M</sup>	4270 <sup>M</sup>	77 <sup>B</sup>	1.59
Los Higüeros	Claudia Pérez	6.5	52.7 <sup>A</sup>	2.63 <sup>M</sup>	3 <sup>B</sup>	122 <sup>M</sup>	3742 <sup>M</sup>	162 <sup>M</sup>	1.53
	Jova Pérez	5.1	116 <sup>A</sup>	5.81 <sup>A</sup>	1 <sup>B</sup>	134 <sup>M</sup>	969 <sup>M</sup>	145 <sup>B</sup>	3.36
	Rosa María López	6.3	60.8 <sup>A</sup>	3.04 <sup>M</sup>	1 <sup>B</sup>	143 <sup>M</sup>	5580 <sup>M</sup>	130 <sup>B</sup>	1.76
Higüero Quemado	Gregoria Murillo	6.2	59.5 <sup>A</sup>	2.97 <sup>M</sup>	1 <sup>B</sup>	186 <sup>M</sup>	2257 <sup>M</sup>	124 <sup>B</sup>	1.73
El Plantel	Dominga Hernández	5.9	102 <sup>A</sup>	5.12 <sup>A</sup>	3 <sup>B</sup>	293 <sup>A</sup>	5000 <sup>M</sup>	347A	2.96
	Marcia Inés Pérez	6.12	35.1 <sup>M</sup>	1.76 <sup>B</sup>	2 <sup>B</sup>	289 <sup>A</sup>	6670 <sup>A</sup>	354 <sup>A</sup>	1.02
	María de la Cruz Gutiérrez	6.39	93 <sup>A</sup>	4.65 <sup>A</sup>	2 <sup>B</sup>	276 <sup>A</sup>	6590 <sup>A</sup>	304 <sup>A</sup>	2.70
La Patastera	Hilda Gonzales	6.2	54.6 <sup>A</sup>	2.73 <sup>M</sup>	1 <sup>B</sup>	421 <sup>A</sup>	4959 <sup>M</sup>	311 <sup>A</sup>	1.58
	Arcadia Hernandez	4.8	32.5 <sup>M</sup>	1.63 <sup>B</sup>	2 <sup>B</sup>	129 <sup>M</sup>	800 <sup>M</sup>	90 <sup>B</sup>	0.94
Buenos Aires	Agustina Mejía	5.39	69.6 <sup>A</sup>	3.48 <sup>M</sup>	2 <sup>B</sup>	55 <sup>B</sup>	380 <sup>B</sup>	38 <sup>B</sup>	2.02
Santa Cruz	Simeona Perez	6.6	54.6 <sup>A</sup>	2.73 <sup>M</sup>	1 <sup>B</sup>	299 <sup>A</sup>	9660 <sup>A</sup>	483 <sup>A</sup>	1.58

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