CIAT research on improving livelihoods of smallholder coffee producers in Nicaragua.

Genowefa Blundo Canto[a], Lisset Perez[a], Victor Zuluaga Gonzalez[a], Peter Läderach[b,c]

[a]Centro Internacional de Agricultura Tropical
Impact Assessment Unit
[b]Centro Internacional de Agricultura Tropical
Climate Change
[c] Research Program on Climate Change, Agriculture, and Food Security, Consortium of International Agricultural Research Centers and Future Earth

Executive Summary

In Mesoamerica, coffee production forms the backbone of thousands of families' livelihoods, mainly smallholders with less than 5 hectares. Despite their size, their contribution to agricultural GDP is strong, representing 20%-25% of export revenues in Nicaragua and Honduras. Yet climate forecasts predict severe impacts from climate change, which might put further strain on other vulnerability factors such as price volatility and market stresses (Eakin, 2006; Läderach et al., 2010b). Hotter climate, leading to poorer cup quality due to early ripening of coffee berries; less and more erratic precipitation, reducing water supply; expansion in the altitudinal range in which the fungal disease coffee rust (*Hemileiavastatrix*) and the coffee berry borer (*Hypothenemushampei*) can survive; extreme climate events and general variability, affecting harvesting in the short and long-term, are some of the potential impacts of climate change on this crop. To strengthen the adaptive capacity of farmers today and improve livelihoods, the International Centre for Tropical Agriculture (CIAT - Centro Internacional de Agricultura Tropical) has worked closely with Catholic Relief Services (CRS) and other partners in Nicaragua since 2009, identifying vulnerabilities and designing alternative strategies, technologies, practices and crops.

The results of CIAT's studies have provided the scientific basis for the collaborative design and implementation of a series of CRS-led projects, also providing recommendations and lessons learned from each project into the proposal and implementation of the next. In this study, we specifically evaluate the short-term impacts of a project for the improvement of smallholder coffee producers' livelihoods carried out in Nicaragua by CRS with collaboration from CIAT between 2011 and 2014. The project, called *"BRIDGES: Bridges from Scarcity to Sufficiency"* was the latest in a chain of interventions in Nicaragua led by CRS, and to which CIAT has contributed since 2009. Based on data collected in 2014 to help design and to assign treatment and control groups for a new CRS project (*Resilience to Rust*), which include information on BRIDGES participants, our findings show that participation in the BRIDGES project has increased months of adequate food provision (MAHFP) for project beneficiaries by 0.3 months, by increasing economic access to food via increased production. Participation in BRIDGES appears associated with an increase in bean yields, of about 230 kg per hectare, and in an increase of almost one income source, however these results are sensitive to different model specifications. Finally, participations in BRIDGES appears associated with a 6% reduction in household dependency from coffee income.

Table of Contents

List of Tables

List of Figures

1. Introduction: Impacts of Climate Change on Coffee Production in Central America and Nicaragua

Research conducted by CIAT projected significant loss of coffee suitability in Central America's premier coffee-growing regions by 2050 as a result of changing climate patterns (Läderach et al., 2008; Läderach et al., 2010a). Climate models predict that the mean annual temperature in Mesoamerica will rise 2-2.5 ºC and that Honduras, Mexico, and Nicaragua will likely experience the greatest increases. Higher temperatures speed up the ripening of coffee berries, leading to poorer cup quality (Läderach et al., 2010b). Models predict lower annual rainfall, especially in Honduras and Nicaragua with decreases on the order of -5% to -10%, which could constrain coffee cultivation and some methods of processing. Pest and disease prevalence will increase as a result of changes in temperature and rainfall, expanding the altitudinal range in which the fungal disease coffee rust (*Hemileiavastatrix*) and the coffee berry borer (*Hypothenemushampei*) can survive. Climate change models for Mesoamerica also predict greater frequency and intensity of extreme weather events, which can irreversibly destroy coffee producing areas have long-term effects through farmer indebtedness and poverty traps (Läderach et al., 2010b).

In practice, the optimal altitude to grow coffee is likely to increase from 1200 m at present to 1400 m in 2020 and 1600 m in 2050, putting at risk especially the origins of specialty coffee varieties, such as Antigua, Guatemala, and Las Segovias, Nicaragua. Different impacts will affect farmers at different altitudes, as the winners will be smallholders who are currently at altitudes too high for the production of specialty-grade coffee, and the losers those currently at the lower viable bounds for its production. For vulnerable smallholder farmers, who will suffer the greatest changes in livelihoods due to climate change, understanding its likely impacts and develop strategies to adapt is crucial.

In Nicaragua, coffee is the largest national export (18.2% of total exports), about 44,519 coffee farmers' families rely on its production, cultivating about 127000 hectares (180219.7 *manzanas* in the local metric). About300,000 people are employed full-time or seasonally in the industry, representing 53% of employment in the agricultural sector and 14% of national employment. Declines in prices at the beginning of the decade significantly affected production, and the sector's recovery was likely compromised by climate variability in later years, e.g., during El Niño of 2006. Currently, the effects of coffee rust continue to be seen in Nicaragua. In 2013, the coffee sector lost seventy million dollars as a result of the damage caused by the rust, in addition to the loss of 32,000 jobs (CRS, 2014b). According to Läderach et al. (2010b) the predicted national production area for 2050 is 16,700 ha, down from 114,600 today. This equates to a 98,200 ha, or 85%, decrease. Coffee production is expected to shrink from 60,900 to 11,200 tons—an 81.6% decrease. All this translates to an expected income loss of over US$74.7 million in 2050 alone, an 82.9% decrease from 2010.

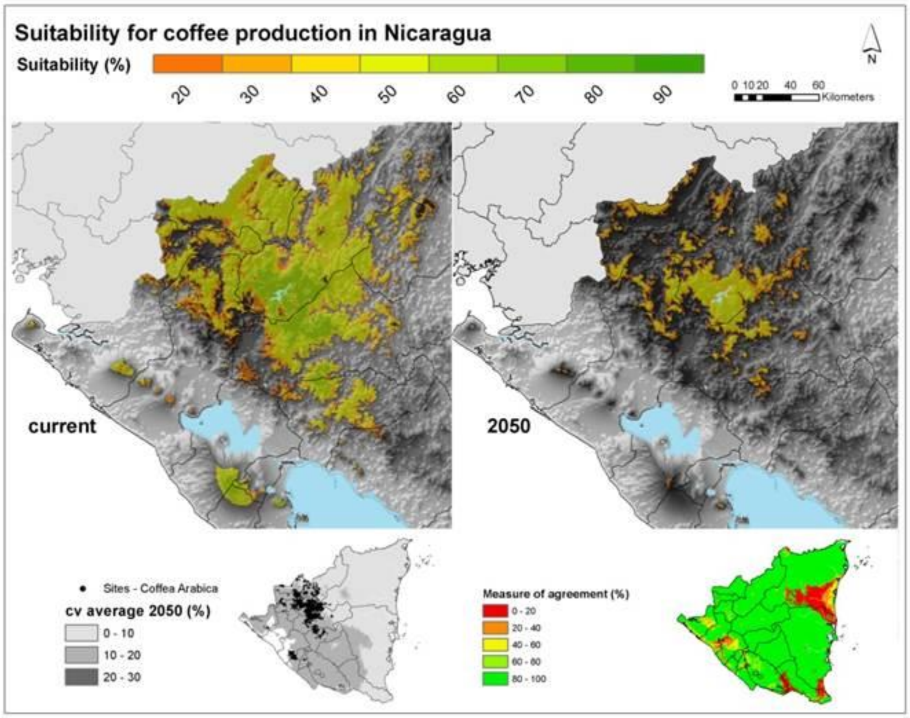
Läderach et al. (2010a) quantified the impact of climate change on the suitability of land to produce coffee in Nicaragua[1] through the MAXENT[2] model, which shows that currently the most suitable coffee-producing

---

[1] With regard to extreme conditions, maximum temperature of the hottest month is predicted to increase from 28.6°C to 31.5°C in Nicaragua and from 29.6°C to 32.8°C in Veracruz, while the warmest quarter will get hotter by 2.4°C in Nicaragua and by 2.6°C in Veracruz. The minimum temperature of the coldest month is predicted to increase from 14.3°C to 16.1°C in Nicaragua and from 11.8°C to 12.8°C in Veracruz, and the coldest quarter will be 2.2°C hotter in Nicaragua and 2.0°C in Veracruz. The wettest month is predicted to be somewhat drier with 270 mm instead of 280 mm in Nicaragua and with 345 mm instead of 350 mm in Veracruz, while in the wettest quarter the precipitation decreases by 50 mm in Nicaragua and by 40 mm in Veracruz. The driest month will be drier

areas in Nicaragua are Nueva Segovia, Jinotega, Madriz, Estelí, Matagalpa, Boaco, and smaller regions on the border of Masaya, Carazo, and Managua. The predicted trend is one of general decreases in the area suitable for coffee and a decrease in suitability within these areas (Figure 1).

FIGURE 1: SUITABILITY FOR COFFEE PRODUCTION IN NICARAGUA



Source: Läderach et al., 2010a

The areas that in 2050 will still be suitable for coffee production are mainly areas that currently show particularly high suitability. In 2050, the dominant area with suitability between 50-60% is in southern Jinotega, northern Matagalpa, and some other small areas in these departments. Areas with suitability between 30-50% will be in Nueva Segovia, on the border to Honduras, in Madriz, Atlántico Norte, and Boaco. The areas that will suffer the greatest loss of suitability loss (loss of 40-60%) are located in the departments of Nueva Segovia, Jinotega, Matagalpa, Boaco, and on the border of Carazo, Masaya, and Managua. The areas that lose least suitability (loss of 20-40%) are located in Estelí and Madriz. Some small areas that until 2050 will likely have an increase in suitability between 20-30% are located in Atlantico Norte, Estelí, Jinotega, and Madriz. At a supply-chain level, the absolute capacity of the regions to produce coffee will be affected, as well as the quality of the coffee produced. Läderach and colleagues identified three main options for coffee producers in zones with decreasing climate suitability: adaptation, switch livelihood sources, or migration upwards. Adaptation could take the form of improved agronomy and sustainable management of resources; a restructuring of the coffee chain and increase in collaborative networks for strategic investments. The coffee chain in Nicaragua is in fact characterized by weak institutions, including the absence of an institution to coordinate, direct or encourage research on coffee and help build consensus among different

---

with 20 mm instead of 25 mm in Nicaragua and drier with 20 mm instead of 40 mm, while the driest quarter will be drier by 10 mm in Nicaragua and by 40 mm in Veracruz (Läderach et al., 2010a).

[2] Maximum entropy (MAXENT) is a general-purpose method for making predictions or inferences from incomplete information (http://www.sciencedirect.com/science/article/pii/S030438000500267X).

groups(forthcoming).It has to be noted that Nicaragua is the only coffee producing country without a national coffee institute and that it is not part of the regional coffee programs (PROMECAFE). There is some movement from the ground to increase organizational strength, as 12 marketing cooperatives formed the Association of Small Coffee Producer Cooperatives of Nicaragua (CAFENICA), through which they collectively invest in capacity building to meet common economic and environmental challenges.

Capacity building to raise coffee growers' awareness of climate change paired with financial transfers can encourage improved management. Developing and implementing wildfire management plans, in preparation for drier future climates, is another strategy that policy makers should take into account (Läderach et al., 2010b).

Part (67.9%) of the current production areas where coffee will likely lose suitability will remain apt for a range of other crops. Diversification for long term crop substitution is therefore a potential adaptation strategy: fruit trees, cocoa and Robusta coffee are more suitable for the projected climatic conditions. In these regions, programs to promote the productive diversification may be successful. However, there are also regions (28.6%) were both coffee and other crops will lose suitability, mainly due to decreased rainfall. In such cases, non-agronomic options for economic diversification will have to be pursued. For instance, the World Bank carried out an impact evaluation of a one-year government program to diversify incomes beyond small-scale farming in Nicaragua to understand how families can better manage risks (Macours et al., 2012)[3]. Two years after the program ended, families who received either investment grants or vocational training were better protected against weather shocks than families who only received conditional cash transfers (CCT) or didn't receive anything, and even managed to stabilize or increase their consumption and income level.

Finally, families might be willing to migrate to more suitable climates, however higher altitude areas are often protected forest reserves that provide important environmental services to lowland populations, so there may be legal constraints linked to property rights and/or environmental concerns.

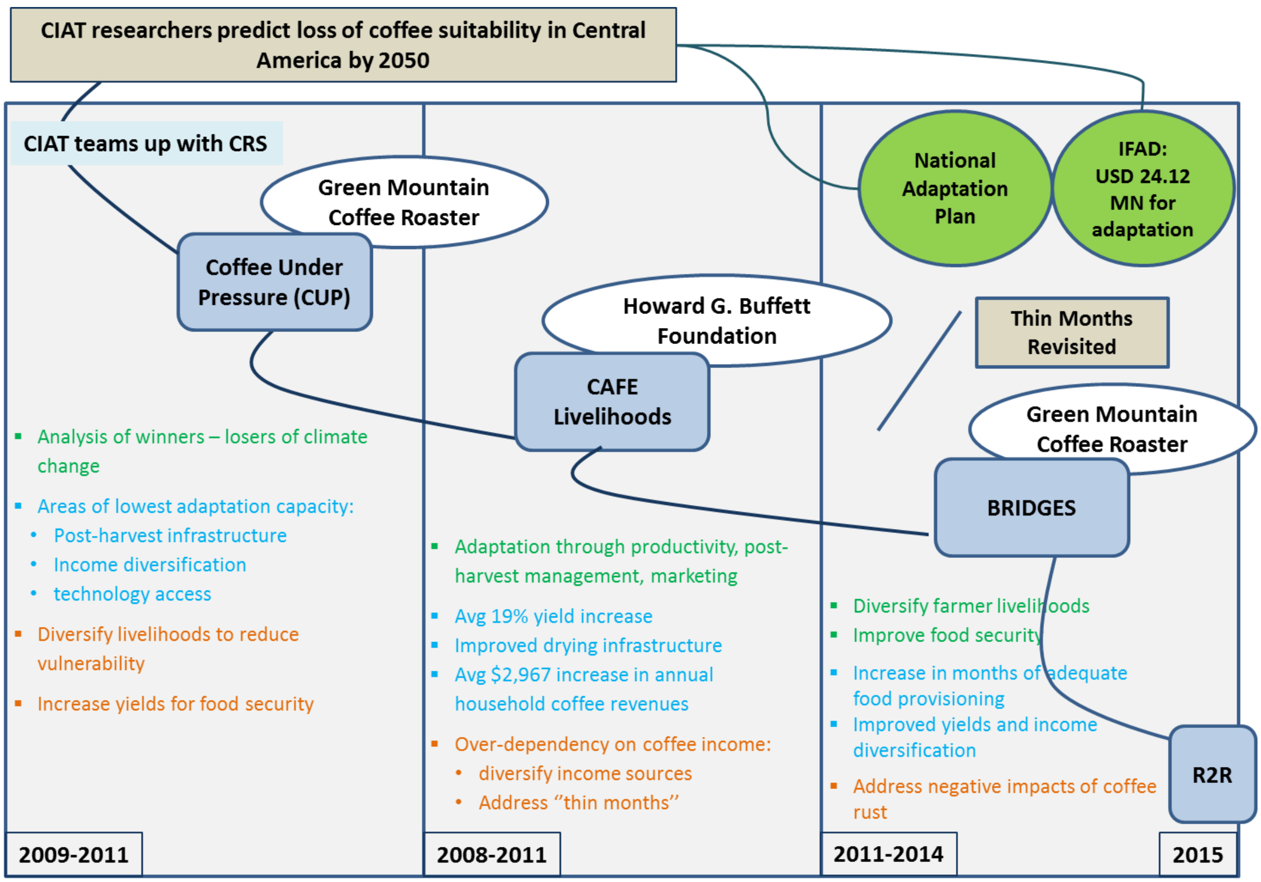
Läderach and colleagues therefore calls for making adaptation to climate change a priority given the importance of coffee for Mesoamerican economies. Key recommendations are the development of climate stress-resistant coffee varieties, improved agronomic management strategies and market links; more financial assistance through direct payments or premium price rewards to sustainable practices and conservation; crop diversification as a risk management strategy and for long-term substitution; and institutional strengthening of the coffee chain.

[3]The study evaluates a one-year pilot government program targeting farming families affected by a severe drought in 2004, which aimed to help families cope in the short-term with cash transfers, provide families with vocational training and investment grants for medium-term diversification from agriculture. The final objective was to allow households to diversify their income sources as a risk management strategy against future droughts or severe weather conditions. A Randomized Control Trial (RCT) with four groups (control group; conditional cash-transfer (CCT) treatment groups; CCT and vocational training treatment group; CCT and non-agricultural business development treatment group) was carried out. The study showed that the first treatment group increased their consumption level compared to the control group in the year of the implementation but did not maintain this level after the program ended, however their diets appeared to have improved. The second treatment group maintained the same consumption level despite climatic shocks; and the third treatment group improved their consumption levels and increased their income compared to the control group despite experiencing climate shocks.

2. CIAT's Climate Change Work in Nicaragua: the Impact Pathway

Since 2009, CIAT has strongly contributed to the development of several projects in Nicaragua providing scientific analyses, applied research and technical support. The recommendations of this work were adopted to prioritize actions and options for adaptation. In fact, a series of projects closely linked to each other has been developed consequently, in a learning innovation process. This impact pathway, developed through a chain of related interventions mostly in partnership with Catholic Relief Services (CRS) and focused on improving the livelihoods of smallholder coffee producers while increasing current adaptation to climate change, is shown in Figure 2.

FIGURE 2: IMPACT PATHWAY OF CIAT RESEARCH FOR IMPROVED SMALLHOLDER COFFEE PRODUCTION IN NICARAGUA



Note on shapes: Ovals - donors; Rounded squares – projects; Squares – research publications; Circles – Policies.
Note on text colors: Green – activities; Blue – results; Orange – recommendations.

CIAT has provided research to support development projects following a clear impact pathway from scientific analysis, to technical support to implementation by development partners. The contribution of CIAT to these projects has been focused on research on the impacts of climate change on coffee producers' livelihoods, generation of scientific information, collection and analysis of data from samples of coffee producers, identification of vulnerabilities and production or technological alternatives for producers, organizations and institutions. These results have provided the scientific backbone for the collaborative design and implementation of a series of development projects, also providing recommendations and lessons learned from each project into the proposal and implementation of the next.

The research led by CIAT has also contributed to practice change in policy makers, informing the National Adaptation Plan (NAP) for agriculture passed by the Nicaraguan government in 2013, a political pledge especially to deal with drought, which strongly affected the country in 2012 and 2013[4].The NAP attracted major investment for adapting coffee production to climate change. IFAD committed USD 24.12 million to facilitate productive investments and provide technical assistance to improve productivity, increase adaptation capacities of poor smallholder producers, strengthen public institutions and policies, and improve weather information systems. An important part of the project will be working with the government to provide incentives for farmers to take measures to adapt. This was complemented by a pledge to strengthen relevant public institutions and policies oriented at providing improved climate-proofed inputs to production, improved information systems on weather events, as well as a general strengthening of the public sector to formulate incentive-based public policies for smallholder farmers.

In addition to these investments, private sector investments were also leveraged based on CIAT's research. In 2012, Green Mountain Coffee pledged more than USD 5.3 million in grants to support food security efforts by NGO partners throughout their supply chain, leading to direct benefits to smallholder farmers[5]. One of the projects resulting from these investments is the BRIDGES project, for which this study provides an evaluation of its socioeconomic impacts.

In the next paragraphs we summarize the projects that were supported by CIAT research on climate change in Nicaragua, leading to the specific project for which the impact assessment study was carried out, the BRIDGES project, which is detailed in section 3.

2.1. Coffee Under Pressure: Climate Change Adaptation in Mesoamerica (CUP)

Objective

CRS and CIAT team up in response to a request for proposals from Keurig Green Mountain (formerly Green Mountain Coffee Roasters) to identify the livelihood vulnerability of smallholder coffee producing families in Nicaragua and to create guidelines for adaptation strategies to respond to climate change.

Summary

In 2009, the joint proposal titled Coffee Under Pressure: Climate Change Adaptation in Mesoamerica (CUP), won a USD 200,000, five-year grant led by CIAT and co-implemented by CRS. The methodology was based on the combination of current climate data with future climate change predictions from 20 models for the years 2020 and 2050. CIAT geo-referenced data points in communities of interest to CRS and generated estimates of the impact of climate change on coffee and a broad range of alternative crops in these communities. These projections identified which crops are likely to be "winners" and which will be "losers" under the most likely climate change scenario. Through participatory analysis of farming practices, economic

[4] NAP Outcome: http://ccafs.cgiar.org/research/results/national-adaptation-policy-adopted-nicaragua-and-resulting-investments-coffee-and#.VK60LSe0SCw
[5] This is the reference: http://ccafs.cgiar.org/research/results/national-adaptation-policy-adopted-nicaragua-and-resulting-investments-coffee-and#.VODvffmG_y4

activities, household and community assets, CIAT generated assessments of local coping capacity and vulnerability in each community.

Scientific outputs

The Coffee Under Pressure project started from recognizing that vulnerability in the management of natural resources equals risk. Within the framework developed in the project, vulnerability is the combination of three factors: exposure, sensitivity and adaptive capacity (Läderach et al., 2012). High exposure is defined according to the projected change in suitability for coffee production in 2050, while several key indicators define sensitivity and adaptive capacity. In Nicaragua, it was projected that families in Madriz department have lower exposure to climate change by 2050. Still, they have high sensitivity (in terms of reduced production by 50-92%, an increase in permanent migration of family members, and degradation of water resources and forest cover). When combined with low adaptive capacity of these families (as indicated by the sub-standard postharvest quality of coffee and minimum conservation efforts in the local river basin), preliminary analyzes of CUP suggested that small producers in this region will be affected by increased food insecurity in the coming years unless they take further measures to reduce their sensitivity and increase their adaptability. Diversifying livelihoods to increase returns in products different than coffee, such as beans and maize or forest products, was suggested to reduce vulnerability and increase their adaptive capacity.

CIAT researchers also identified that coffee farmers strongly perceive changes in climate seasonality, which affects their production systems, particularly flowering, yields, crop management, and reduces water availability due to frequent drought (Baca et al., 2011). About 18% of 150 families sampled were found as highly vulnerable to climate change, mainly located in the municipalities of El Tuma-La Dalia, El Cuá and Quilalí, while about 52% presented medium vulnerability. High vulnerability was associated with high and medium exposure, indicating that future climatic conditions will not be favorable for coffee production where their farms are located (coffee being their main source of income) if no adaptation measures are undertaken. High vulnerability is associated among other with low access to means of transportation for marketing, low viability of post-harvest infrastructure, low conservation of natural resources and soil fertility, reduced health, nutrition and high migration, and with low social and financial resources. The lowest adaptation capacity is related to post-harvest infrastructure, especially drying, diversification and access to alternative technologies. Families identified the following options for adaptation to climate change through participatory workshops in Jinotega, Las Sabanas, Matagalpa, and Quilalí: conservation of natural resources, increased access to education, sensitization of key actors in conservation, strengthening of local organizations, law enforcement and improved access and availability of credit programs. The main requirement to contribute to families' food security is to increase yields and reduce high yield variability.

Main Outputs on the Ground

The innovative approach of CUP was modified and applied to other CRS projects focusing on basic grains in Central America. Specifically for Nicaragua, findings from CUP were incorporated in the proposal for the following CRS project supported by CIAT, so called CAFÉ Livelihoods.

2.2. Coffee Assistance for Enhanced Livelihoods (CAFE Livelihoods)

Objective

Coffee Assistance for Enhanced Livelihoods (CAFE Livelihoods) was a three-year, four-country project led by CRS and funded by the Howard G. Buffett Foundation (HGBF) that proposed to help 7,100 smallholder farmers in Mexico, Guatemala, El Salvador and Nicaragua by expanding and sustaining their participation in high-value coffee markets, through increased and sustainable coffee production, improved production practices, and organic certification.

Summary

Through a value-chain approach, and leveraging on the results of CUP project, Café Livelihoods focused on the development of adaptation strategies including diversification and post-harvest processing and management, and marketing (CRS, 2011). The project included multiple and complementary interventions along the coffee chain, and enlisted the technical assistance of Cooperative Coffees and Root Capital, sustainability leaders in smallholder coffee finance and marketing, respectively. The project began on 1 October 2008 and came to a close on 30 September 2011. The project focused on a range of constraints starting with increasing production volume passing through improved post-harvest management and organizational strengthening and concluding with the facilitation of improved market linkages (Lundy, 2011).

Scientific Outputs

The research carried out by CIAT in CUP provided the scientific basis on which CAFÉ Livelihoods was developed. CIAT also conducted an independent external desk review of the CAFE Livelihoods project: CRS asked CIAT to evaluate the project against the internal performance standards agreed upon between CRS and HGBF, and comparing it externally to similar projects (Lundy, 2011).

Main Outputs on the Ground

Among main results for the four countries: through improved agronomic practices and heavy investment in renovation for aging coffee fields, project data showed an average increase in yield of 19 percent; project expanded access to new and/or improved wet-milling infrastructure for 1,945 smallholder farmers, and to new and/or improved drying infrastructure for 1,913 smallholder farmers, improving their ability to meet specialty market quality standards; average increase in annual household coffee revenue for project participants was $2,967, and participating cooperatives recorded more than $6.3 million in increased sales revenues (CRS, 2011). Despite these gains the project fell short of its goals in overall productivity gains – 89% of farmers for whom the project gathered data during all three years of the project achieved over 10% greater productivity – and in the promotion of organic production with currently non-certified farmers (Lundy, 2011). In post-harvest management, the project succeeded in increasing farmer access to improved wet and dry milling facilities, in helping participant organizations meet their commercial commitments and in increasing the number of famers selling fully processed coffee; exceeding in its goals in terms of the number of organizations implementing coordinated post-harvest and transportation strategies which has a direct bearing on coffee quality. Despite these gains, the self-reported gains in cupping scores were far less than initial targets (Lundy, 2011). In marketing, the project exceeded its targets in terms of the volume of coffee sold into specialty markets and as roasted coffee to national markets.

2.3. *Thins Months Revisited*

Objective

In 2013, Keurig Green Mountain worked with CIAT and the Agroecology and Rural Livelihoods Group (ARLG) at the University of Vermont, USA, to replicate a study of coffee farmers' welfare in Guatemala, Mexico, and Nicaragua, which CIAT originally conducted in 2007 (Fujisaka, 2007) and understand if the same issues continue or if they have changed.

Summary

A key finding of the study carried out by CIAT in 2007 on coffee farmer welfare was that the majority of coffee producing households experienced 1–8 months of seasonal hunger (a period referred to locally as the "thin months"). Subsequently, the following Keurig Green Mountain projects focused on such activities as diversification of employment and food production, and education scholarships. To determine changes to understand the effectiveness of Supply Community Outreach interventions, they approached CIAT and the Agroecology and Rural Livelihood Group (ARLG) at the University of Vermont in 2013 to conduct a 'revisit' of the original study, surveying the same households (Baca et al., 2013). The 2013 sample for Nicaragua included farmers from the CECOCAFEN association in Matagalpa and Jinotega (2007 n=33, 2013 n=28, surveyed both years n=21). Results showed improvements in terms of months of household food security and coffee production, with some reduction in the dependency on coffee income but still an average 3-4 months of food insecurity and a significant need for credit.

Scientific Outputs

As revealed in the original 2007 study, the period of food shortage tends to occur annually during the rainy season, and this type of food insecurity is referred to as "seasonal" (Caswell et al., 2012). The majority of families defined food shortage as having the income or resources to provide a certain part of their basic diet but not enough to diversify their diet and/or consume the necessary and/or desired quantities of food. For the families participating in both the 2007 and 2013 surveys, the reported average number of thin months across sites decreased from 3.81 in 2007 to 2.84 in 2013. This represents a reduction of nearly 1 month, on average. Despite this improvement, the majority of people interviewed in the three countries during 2013 still considered that they have no guarantee of food security for 3–4 months out of the year.

Another finding was that the land allocated to maize and bean cultivation (*milpa*) declined, while land allocated to coffee appeared to have increased. Average coffee production also rose by about two-thirds. Although the production of coffee remained farmers' most important source of cash, subsistence food production tempers farmers' apparently high degree of dependence on coffee. In Nicaragua, the percentage of households reporting access to credit decreased from 82% in 2007 to 64% in 2013 because of reduced availability of funds for loans and increased restrictions on lending from some cooperatives. According to the study, average coffee production in Nicaragua rose by about two-thirds, but compared to the other countries in the study it also showed the lowest average price over the 5 years of coffee price data ($1.57/kg or $0.71/lb). Reasons for this included quality standards, limited market demand, cooperative quotas, and the need to sell a portion of the harvest to intermediaries for "cash in hand" during the harvest season. The percentage of income that farmers derived from coffee was also inversely related to the number of thin months in 2013. These data suggested that households may be investing more of their cash income to address food security – a conclusion supported by Nicaraguan farmers' high degree of awareness about this issue.

Another important trend observed in the 2013 study was the shift away from pure dependence on coffee to more diversified livelihood strategies. In 2013, farmers in all three countries singled out coffee as their households' most valuable source of cash income, followed by diverse small businesses (including stores or bodegas, sewing, cooking for events, and cheese making), the sale of other agricultural goods, apiculture, nurseries, off-farm employment, and financial support from government programs (which amounted to 13% of household income in Nicaragua, 19% in Mexico, and 20% in Guatemala). In all three countries and in 2007 as well as 2013, coffee contributed more than 70% of total cash income, on average, followed by other activities (averaging 16–28%).

In the 2013 study, farmers also assessed the percentage contribution to their livelihoods of a range of non-cash and cash assets. Besides coffee, these include various agricultural goods produced on a subsistence basis as well as poultry and other livestock. Farmers consider goods produced on a subsistence basis – maize, beans, plantains, other fruits, vegetables, and animal products – to have significant value, as these items are either directly consumed by the family or traded through community bartering systems. Especially in Nicaragua and Guatemala, farmers perceived the production of maize and beans to be just as important for their livelihoods as the other activities.

Main Outputs on the Ground

The findings from the Thins Months study show that months of adequate food provisioning, livelihood diversification, improved maize and bean production, and access to financial instruments are, among other things, fundamental dimensions for the study of food security in Mesoamerican countries. Among key recommendations the study focused on the need for deeper analysis of the conditions under which income, crop, and land-use diversification strategies are most favorable and how their synergies or trade-offs influence farmers' overall well-being (Caswell et al., 2014). Effective strategies to increase food security are considered those designed with active farmer participation, leading to greater control over food access and food type. Participatory research and technical assistance focusing on site-specific agricultural management practices with emphasis on making production more resilient, and focusing on increasing access to credit for farmers are also strategies recommended.

Box 1: Other CIAT activities in Nicaragua

Carbon Insetting

Under the funding of Green Mountain Coffee Roaster, PUENTES and Carbon In-setting were started with CRS in 2012. Carbon Insetting looks at how agrobiodiversity conservation can be rewarded (with PRODECOOP). A Consortium was formed to develop a payment-for-ecosystem-services project aimed at improving smallholders' livelihoods, while mitigating climate change and making agricultural systems more climate resilient. The Consortium members are CIAT, FLO-CERT, Catholic Relief Services (CRS), Sustainable Food Lab, four Nicaraguan coffee cooperatives, and a private-sector partner. Together, the partners possess a large body of knowledge and experience of applied climate science, adaptation and mitigation strategies, and GHG measurement and are actively involved in projects with Nicaraguan farmer organizations as well as in strong learning networks and relationships with current and potential global stakeholders in carbon projects.

Tortillas on the Roaster

The project "Tortillas on the Roaster" seeks to predict site-specific changes in maize-bean production systems in order to inform and enable vulnerable farmers to act and respond to ongoing climate change through specific adaptation measures and increased capacity.

CECOCAFEN Central de Cooperativas Cafetaleras del Norte R.L.

Central de Cooperativas Cafetaleras del Norte R.L. is a cooperative of 2,637 smallholder coffee growers located in Matagalpa, Northern Nicaragua, 130km from the capital Managua. They use the methodology and studies from CIAT, adapting them to their needs and to orientate their work plan. In 2014 they distributed to their associates a brochure on climate change and its consequences for coffee producers reporting the suitability analysis developed by CIAT. The brochure lists a series of practices that can be adopted to face climate change. CECOCAFEN also worked on a project of carbon sequestration with CIAT, through which a mathematical formula to calculate the amount of carbon stored in plants was tested. Through this project, the producers have combined coffee with other trees, which has enabled them to sequester carbon sequestration and improve their crops.

3. The BRIDGES Project

Objective

Bridges from Scarcity to Sufficiency (BRIDGES or PUENTES in its Spanish version) was a 3 year project (2011-2014) funded by Keurig Green Mountain and conducted by Catholic Relief Services with scientific collaboration from CIAT with the goal to diversify livelihoods and improve food security in the coffee growing regions of Central America.

Summary

BRIDGES started from the recognition based on the previous projects that smallholder farmers' incomes were overly dependent on coffee, potentially increasing the vulnerability of farmers to market fluctuations and sudden pests and diseases, and that food security was based on the traditional diet of maize and beans, with very little diversification. In particular, income generation from coffee is focused in the harvest months between September and January, and household resources start to draw thin in March. During this 'thin' period, about half of producers suffer from food shortages for 3-4 months and in particularly "bad years", when prices fall or production is low, these are further exacerbated. Low income generation can also affect future coffee production by reducing ability to invest in crop management and processing. Climate change in the form of storm and drought frequency and intensity puts further strain on the livelihoods of producers, especially in areas that have been identified as likely loosing suitability for Arabica varieties, which wage a higher price on the market.

To help address these problems, CRS proposed a three year project for the diversification of farmer livelihoods through income and asset expansion to increase monetary stability throughout the year and resilience to coffee income volatility. In a continuum with the CUP project, CIAT researchers evaluated the impact of climate change on coffee smallholders' livelihoods and determined the climatic suitability for coffee (Coffee Arabica) and other potential crops as alternatives for diversification at the local level. Moreover, CIAT researchers developed a participatory inventory of relevant agronomic technologies known or applied by farmers and technicians in the area to identify sustainable alternatives to current practices for coffee, maize and beans that are locally known.

Following from CUP, the proposal for BRIDGES recognized that in Nicaragua low adaptive capacity of the families, as indicated by sub-standard coffee postharvest quality and minimum conservation efforts in coffee producing areas, could pair up with increased food insecurity in coming years unless new measures to reduce vulnerability and increase adaptability are taken. In 2010, CIAT researchers estimated that on average, 68% household income came from coffee, 15% from maize/beans, 14% from forest products such as timber, and only 3% from other products, animals and agricultural commodities. Diversifying livelihoods to increase the importance of these other categories relative to coffee, thereby allowing better overall balance was identified as a mean to increase adaptability of households and reduce vulnerability.

In order to improve livelihoods and food security in coffee growing communities, CRS proposed a three-year project to diversify sources of income and assets, improving the stability of income generation throughout the year and increasing resilience to volatility in revenue generated by coffee.

With the aim to increase food security through sustainable improvement of living standards of coffee producing households, two specific objectives were set. The first was to mitigate risk of families through increased and diversified agricultural production, especially basic grains, fruits and vegetables, and incentivizing animal or honey production. To this purpose, CIAT identified best agricultural practices locally available through initial diagnosis with farmers and technicians, to reduce the use of synthetic fertilizers and pesticides, to improve soil conservation and use of live barriers, contour planting and tillage farming methods. Training on processing and marketing opportunities for existing production was also part of the diversification of production with the aim to strengthen value chains. The initial proposal included the establishment of small innovation funds and the promotion of integrated water resources management, however these two areas were not the focus of implementation considering the small size of the project grant. The second specific objective of the project was to increase the financial and social capital of families through savings groups, a methodology previously implemented by CRS in other projects. This is based on groups of 10-20 people who meet regularly to save and provide loans to members of the group. Savings groups provide an immediate mechanism to manage scarce resources and provide lump sums of money when poor families face unexpected financial needs. The idea is also that savings groups increase social capital and cohesion among participating families. CRS aimed to focus the saving groups to women in order to promote greater equality in financial assets in households where the income generated by coffee usually is controlled by men, and promote greater equality in social and political assets in communities where women often are not involved in making decisions that affect their social development. The thematic focus would be based on nutrition given the key role of women in this area, promoting fruits and vegetables with highest nutritional benefits.

To achieve the above, the project focused on technical assistance, training and support to increase yields, efficiency, and product quality in the following areas (CRS, 2014b):

- Production of basic grains, fruits, and vegetables;
- Husbandry of appropriate breeds of poultry, small ruminants, tilapia, and honey bees;
- Prioritization of value chains (honey, bananas, and oranges) that offer additional income opportunities for producers in the four countries;
- Savings and lending group formation as an immediate mechanism for better management of scarce resources, making money available when poor families face unexpected financial needs and, once they reach maturity, investing their capital in small commercial rural enterprises that contribute to greater diversification of family income;
- Training of project participants in income generating activities, good governance, enterprise, water resources, and health and nutrition.

BRIDGES targeted 2714 households but finally worked with 3451 families in Nicaragua, Guatemala, El Salvador and Honduras, as shown in Table 1. In this report we only focus on the activities and results for Nicaragua.

TABLE 1: GEOGRAPHIC TARGETING AND BENEFICIARIES

Table 1: Total Beneficiaries Served by the Project from October 2011 to September 2014					
Country	**Province**	**Municipality**	**Sex**		**Overall Total**
			F	**M**	
El Salvador	Santa Ana	Chalchuapa	226	62	288
	Ahuachapán	Jujutla	368	242	610
Total for El Salvador			**594**	**304**	**898**
Guatemala	Chiquimula	Camotan	25	31	56
		Olopa	158	121	279

Table 1: Total Beneficiaries Served by the Project from October 2011 to September 2014					
Country	**Province**	**Municipality**	**Sex**		**Overall Total**
			F	**M**	
	Zacapa	Gualan	31	49	80
		La Union	155	84	239
		Zacapa	5	7	12
Total for Guatemala			**374**	**292**	**666**
Honduras	La Paz	Cabañas	128	181	309
		Opatoro	122	242	364
		Santa Ana	203	156	359
Total for Honduras			**453**	**579**	**1032**
Nicaragua	Nueva Segovia	Quilalí	25	95	120
	MADRIZ	San Juan del Rio Coco	130	406	536
		Telpaneca	58	141	199
Total for Nicaragua			**213**	**642**	**855**
Grand Total			**1634**	**1817**	**3451**

The scope of the project was very ambitious and potentially too far reaching for a three-year, one-million, four-country project. In this study we will focus on the first area of the intervention, diversification and improvement of agricultural production, partly due to limited availability of data and partly because this area is more likely to show early signs of impact compared to nutrition, social capital and results of financial investment through savings group.

3.1. Scientific Outputs and Activities Carried Out by CIAT

The BRIDGES project presented the opportunity for CIAT to continue the work begun in Coffee Under Pressure, contributing with methods and research to generate adaptation strategies that help smallholder farmers adapt to climate change. These include the identification of suitability scenarios for local crops, of the livelihood vulnerability of coffee producing families and of adequate agricultural technologies. To these purposes, CIAT wrote with CRS the proposal for BRIDGES and applied for a grant to Green Coffee Mountain Roaster. Within the objective of improving farmers' livelihoods CIAT researchers evaluated the impact of climate change on coffee smallholders' livelihoods and identified options for their families and related organizations and institutions (Baca et al., 2011). The objectives of the research were to determine the climatic suitability for coffee growing (Coffee Arabica) and other potential crops as alternatives for diversification at the local level. Further objectives were to assess the vulnerability of Central American smallholder coffee farmers' and their families' livelihoods to climate change, and to establish an inventory of agricultural technologies for coffee families in Nicaragua. The study was conducted in San Juan del Río Coco in Nicaragua, Jujutla and Chalchuapa in El Salvador, Olopa, Camotán and La Union in Guatemala, and Santa Ana, Cabañas and Opatoro in Honduras. According to the results of this analysis the suitability of coffee growing regions in Nicaragua, Honduras and El Salvador will be reduced towards 2050, with the highest decrease in El Salvador. Furthermore, farms located at lower altitudes (600 – 1000 m.a.s.l.) will have a higher decrease in suitability, while in growing regions at higher altitudes (1200 – 1800) suitability will increase. Other potential crops such as maize, beans, citrus, tomatoes, bananas, cocoa, avocado, mango or sorghum will gain, loose or maintain suitability by 2050. High vulnerability was identified in 6% of families in Nicaragua (area of study: San Juan del Rio Coco), 55% of families in El Salvador (area of study: Chalchuapa y Jujutla) and 24% of families in Guatemala (area of study: Camotan, Olopa, La Union) . In Honduras, families did not have high vulnerability. In general, families have high vulnerability when their farms are located in areas where coffee will lose suitability in the future, are highly or moderately sensitive to the variability of coffee production, and have low adaptive capacity for viability of post-harvest infrastructure through forms of drying. When families showed high variability in coffee production, their annual income was reduced and some families reduced their daily diet. In other cases, some members of the household migrated to other regions of the country to look for work and improve household income. Additionally, the lack of infrastructure for post-harvest drying diminishes coffee quality in areas with high humidity and oftentimes families decide to sell the berries or wet parchment to avoid deteriorating the coffee, thus reducing their annual income.

For Nicaragua, the actual suitability model predicted that 86 coffee farms sampled in San Juan del Río Coco had good suitability conditions for coffee production (50-70% suitability) and that by 2050 these conditions would degrade, putting at risk coffee production and quality (Baca et al., 2013). Three exposure scenarios were developed for the cultivation of coffee in San Juan del Rio Coco by 2050, and in the high-exposure scenario 21 farms out of 86 were identified as highly exposed, located at an altitude range between 691 to 963 m.a.s.l. In all three scenarios coffee cultivation looses suitability in 2050, however other crops maintain or gain in suitability, projecting optimum climate for bananas, cocoa, beans, maize and oranges.

In Nicaragua, in addition to loss of suitability of their main income source, the families studied were highly sensitive to variability in coffee production, and affected by migration and low housing quality. They showed low adaptive capacity also due to lack of knowledge of the policies and laws ruling the coffee sector, and of environmental and land use laws, reducing their ability to access resources to improve their livelihoods. Moreover, they had low income diversification, low levels of organization and reduced access to technology.

Agricultural technologies for the main crops cultivated by the coffee farmers were identified by means of a literature review, expert knowledge, farm visits and participatory workshops with technicians and producers in Nicaragua. An inventory of best management practices for coffee, beans and maize, and no agronomic alternatives such as forestry was then created. The purpose of the technology inventory is also to be a tool for decision-making for technicians, producers and organizations, who have a description of traditional practices and of research advances to help them make decisions on coffee, maize and beans management. Identified agricultural technologies included practices that have been in use for 20 years and some practices that have been introduced with the adoption of organic production systems. Some technologies are not accessible to small producers, due to the lack of adequate financing, organization, empowerment of their organizations and access to knowledge, which makes the difference when adopting strategies for adaptation or mitigation to climate change (Baca et al. 2013). In 2014, Zuluaga and Labarta carried out several expert workshops at the national level where they find that technicians perceive a lack of knowledge on best practices to adapt to climate change (forthcoming study). This kind of exercises therefore lack wide diffusion beyond cooperatives included in CRS activities.

In-depth participatory workshops with producers and technicians to describe the farms, and current and past agricultural practices were performed in each country of the BRIDGES project and a baseline survey was carried out. These activities aimed to help CRS define specific targets for key indicators of impact and outcomes; provide inputs to the technical team to identify the types of products to promote and better agricultural practices for both domestic consumption (e.g. grains, vegetables, animals) and for the market (e.g., bananas, honey, etc.); and identify cooperative members willing to lead and/or participate in savings groups, as well as to identify key environmental needs in participating communities (areas for reforestation, protection of water sources, reduced contamination, etc.). The participatory workshops produced insight on major changes: participants agreed that 15-20 years ago there were fewer areas of coffee and fewer plants per hectare, coffee farming was of traditional sort, the forest was cleaned and planted bare root (without seedling in bags) under the shade of native trees. Participants also noted that pests and diseases control was less labor and input intensive. Organic fertilizer application seems widespread, while handling tissues, restocking or renovation with new coffee trees, practices for soil and water conservation, including terracing, contour planting and ditches are traditional practices which were only maintained by few producers.

Finally, a baseline study on a sample of project participants established the targets or objectives against which various indicators of before-after impact were to be measured (CRS, 2014b). According to the baseline study, three levels for food provision were established: Low Level, from three to eight months; Intermediate Level, nine months; and High Level, from 10 to 12 months. The baseline also established the targets to measure the indicators for dietary diversity: Low Level, from two to two food groups; Intermediate Level, from six to seven food groups; and High Level, from eight to 12 food groups.

3.2. Main Outputs on the Ground: the Nicaragua Branch of the Project

In Nicaragua, the project worked with 804 farmers who are members of the cooperatives that supply Green Mountain Coffee Roaster (PRODECOOP, CORCASAN, UCA San Juan del Rio Coco - SJRC). The total budget for the three year implementation in Nicaragua was about USD 1 Million.

Given its role in food preparation, women hold a unique position to improve the nutritional status of their families. Hence some partners and cooperatives identified the need to integrate nutrition awareness and communication to change practices in their livelihood activities and savings groups.

In the first months of implementation of the Bridges project, the families began to suffer food insecurity problems due to the sharp decline in international coffee prices, from its historical high of USD 300 per 50 kg, reached in April 2011, to USD 150 per 50 kg in June 2012, with a 50% decrease in price. Also, most of their income and food security were coming from coffee production, generating high dependence and vulnerability to these fluctuations. There was little production of other crops due to limited areas, financial resources and knowledge. Generating alternatives to break this economic dependence on coffee, was in fact the main aim and challenge of the Bridges project.

In May 2012, a widespread and severe outbreak of coffee rust in Central America, including Nicaragua, affected the 2012/2013 production cycle by more than 20% according to official estimates, and San Juan del Río Coco was the most affected municipality nationwide with more than 85% incidence (FUNICA, January 2013).This damage was prolonged, and its greatest effect was felt in the 2013/2014 production cycle, with a reduction of up to 30% of the harvest due to heavy defoliation and reductions in production areas due to dead plants and pruning.

Rust and declining international coffee prices has also affected the liquidity of producer organizations to support their associates, which coupled with restrained credit from banks, increased the vulnerability and the effects on production and food security of coffee producer families.

To address this situation, the project focused on improving production capacity and dietary diversity of families, and improving their saving capabilities through local entrepreneurship initiatives and partnerships. The following themes were prioritized in Nicaragua: production and management of basic grains, sweet potato, and homegardens; establishment and management of agroforestry systems; preparation and use of nutrients; establishment and management of hives; saving groups; marketing. To this end, key activities in Nicaragua during the three years of implementation included:

- Funding the establishment of 941 manzanas (662 ha) of maize and 889 manzanas (626 ha) of bean.
- Establishing of 217 family gardens and strengthening of 170 homegardens.
- Planting of 426 plots of sweet potatoes
- Promotion of banana and honey as alternatives to diversify and improve income families through funding of the rehabilitation of 897 manzanas (631 ha) Musa and the establishment of 280 hives.
- Training of 68 savings groups, which serve as sources of local funding to meet the specific needs of families and the community.

Technical assistance and training.Specifically, in the last year of the project, 753 people from Nicaragua beneficiaries were trained on diverse issues related to agricultural production, value chains and savings groups. According to analysis by CRS based on the baseline data they collected on the beneficiaries, the application of some practices has changed in large part due to training received. The practices on which people were trained were selected as best practices from the inventory of available technologies for the management of coffee, maize and bean. For the overall project beneficiaries in the four countries, the use of live and dead barriers to halt loss of soil through erosion, conserve water and maintain soil moisture has tripled or doubled among project beneficiaries since 2011, as well as contour planting and appropriate use of chemicals for pest management, and organic fertilizer (CRS, 2014b).

In the last year of the project 24 training workshops were conducted in Nicaragua on production and management of family gardens, and on the use and management micro-drip and spray irrigation systems; 12 workshops on the processing and use of nutritious foods; 19 workshops on the establishment and management of agroforestry systems; and 4 exchange tours on agroforestry systems. These practices were prioritized in the inventory of alternatives developed by CIAT researchers, and in fact about 897 plots in Nicaragua were improved with agroforestry systems.

In Nicaragua, about 370 hectares of coffee agroforestry systems were maintained principally using *musáceas* (bananas and plantain), with which the producers could diversify their incomes. In 2014, they were in the process of developing proposals for the improvement of 263hectares of coffee agroforestry systems (CRS, 2014a).

Sixty-four saving groups were formed in Nicaragua but only half of them graduated. The saving groups have lent USD 22,666 in 2014 to develop income generating initiatives, which in Nicaragua were linked to food sales, the establishment of small stores, purchase and sale of produce (harvest reception centers) and agricultural inputs (CRS, 2014b). In Nicaragua, project partners have had little to no experience in the management of revolving funds and their credit policies have been focused solely on coffee and not basic grains. Given this, the project provided advice on the management of revolving funds and then gave them space so that the partners themselves could define their own credit mechanisms oriented towards food security activities of their members (CRS, 2012).

In terms of value chains, activities in Nicaragua were focused on banana and honey production. About 80 families participated in the honey value chain, where activities included several alliances: with the Multi-service Cooperative Federation, PRODECOOP, and with the INGEMANN Company to establish a channel for sales and technical support; and with the Program for Rural Enterprise Management, Health and the Environment (PROGRESA) and CIAT to develop an inclusive business model in the beekeeping area, with the participation of the three implementing partners for the project and the INGEMANN Company. In the first year of the project, four workshops on Apiary Management Training (disease prevention plan, monitoring costs, profitability, etc.) were carried out and 28 honey producers, assisted by PRODECOOP, were connected to the market. Technical reinforcement workshops were held among the stakeholders and complemented with joint exchange tours among partners and farmers, and a visit to El Salvador to seek new markets (CRS, 2014b). The 82 Nicaraguan honey producers reported 6,955 liters of honey. According to an internal CRS report, beekeeping has great potential in the area of project intervention, however, the number of people that can practice it is relatively small due to its high investment cost and high technical commitment required.

The project experienced difficulty in working on the banana value chain due to the lack of a standard quality for the product in the project area; the lack of a buyer willing to pay for the value added to the product; the financial inability to build a processing plant; and the of project funds to conduct more in depth studies on the local market and the lack of technical personnel in the project (CRS, 2014b). Also, in Nicaragua there was the lowest achievement in terms of increase in income compared to the four country beneficiary baseline: only 14.8% of the families increased their gross income by 10% or more.

4. The Impact Assessment Study

Impact evaluations can rigorously identify program effects by constructing comparison groups for participants. This study employs a quasi-experimental design by defining a control group from a larger database and matching it with the treatment group (the project beneficiaries).The database used in our analysis comes from data collected in 2014 by CRS and CIAT on more than 600 farmers in the departments where BRIDGES was implemented The purpose of the data collection was to suggest a rigorous research design for the *Rust to Resilience* - R2R project by CRS, which will start in 2015. This design would allow setting an ex-post impact evaluation following a regression discontinuity design in the future (2016 and 2018) and control for pre-implementation differences between a suggested intervention group (more vulnerable) and a control group. The Project will work with 400 producers and coffee pickers in the municipalities of San Juan del Rio Coco, Telpaneca and Quilali in Nicaragua and with 700 producers from the Department of San Marcos, Guatemala.

The database collected by CRS and CIAT for R2R includes information about participation in the BRIDGES project: 300 of the interviewed households were BRIDGES participants (self-reported) while 317 members of the same cooperatives did not report participation in the BRIDGES project. We do not know with confidence whether the non-participants in BRIDGES had the chance to participate in the project if they wished, and therefore selection on unobservables is taken into account in the estimation. This allows us to construct a statistical comparison group based on a model of probability of participating in the treatment given observed characteristics: this method is called Propensity Score Matching (PSM) and was developed by Rosenbaum and Rubin (1983) (see Box 2 for further details).

The data were collected on a representative sample of small coffee producers (with coffee areas under 3.5 ha) who are associated with the cooperatives CORCASAN, PRODECOOP and UCA San Juan del Rio Coco in the municipalities of Quilalí in Nueva Segovia, and San Juan del Rio Coco and Telpaneca in Madriz (Table 2)[6]. The sample size was calculated to give statistical power to observe differences between the treatment and control group in the future evaluation.

TABLE 2: NUMBER OF HOUSEHOLDS INTERVIEWED

	Cooperative			
Department	**PRODECOOP**	**UCA SJRC**	**CORCASAN**	**Total**
MADRIZ	165	217	123	505
NUEVA SEGOVIA	112	0	0	112
Total	277	217	123	617

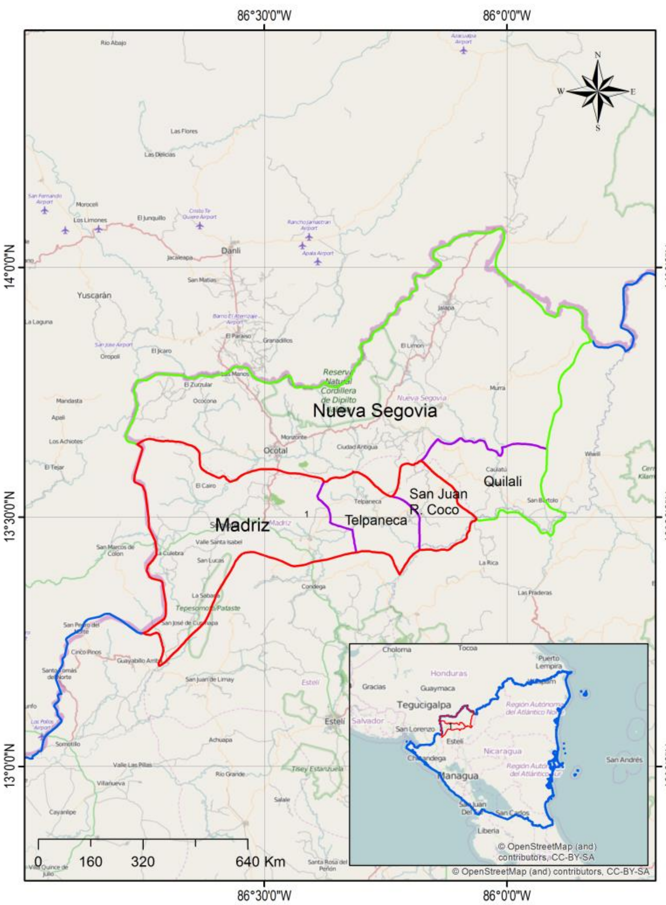
Figure 3 shows a map of surveyed municipalities. The information was collected by technicians of these cooperatives in the second half of 2014, with supervision from CRS and CIAT. The reference period of the survey was the agricultural cycle between May 2013 and April 2014. The database provides data on 617 households from the municipalities of Quilalí in Nueva Segovia (18.15%), Telpaneca and San Juan del Rio Coco in Madriz (24.47% and 57.37% of the sampled households respectively). Household data were geo-

[6] The sample size was determined so that the minimum detectable effect of *R2R* in the poverty rate was 5% with a statistical power of 80% and a significance level of 10%.

referenced in December 2014 and cleaned for potential errors in the attribution of households to the cooperatives or neighboring communities.

The final dataset is based on 617 households as shown in Table 3: 300 of them participated in BRIDGES, while 317 did not. The questionnaire submitted to sampled households provides detailed information on demographic and socio-economic characteristics, food security, dietary diversity, access to public programs, agronomic data of the plots, farm labor, agricultural practices, rural employment, savings, access to credit, social capital, and climatic, economic or family shocks. The information collected aimed basically to build resilience indicators that would allow estimating the vulnerability of the 617 farmers and proposing the research design of treatment and control for the future impact evaluation.

FIGURE 3: MAP OF SURVEYED MUNICIPALITIES



Source: Authors

Despite the data were not collected for the purpose of evaluating BRIDGES they are adequate to assess its short-term impacts: of the 617 households included in the database 300 (48.6 %) are BRIDGES beneficiaries; the sample comes from the same universe in which BRIDGES operated (associate producers of CORCASAN, PRODECOOP and UCA SJRC in the three communities); and any BRIDGES household that fulfilled the 3.5 ha of coffee area required for participation in R2R was included in the sample. Thus the database provides an adequate however imperfect instrument to identify the impacts of BRIDGES on beneficiaries with less than 3.5 ha in coffee. Section 4.2 explicitly addresses the limitations of the study.

TABLE 3: NUMBER OF BRIDGES PARTICIPANTS

	Department		
Bridges Participants	**Madriz**	**Nueva Segovia**	**Total**
No	285	32	317
Yes	220	80	300
Total	505	112	617

4.1. Methodology

In the following section we lay out the methodology applied for the impact assessment study, including the dimensions selected for the analysis of impacts and the estimation method.

4.1.1. Impact Dimensions

In order to assess the impact of BRIDGES we focus on well-being dimensions on which the project aimed to achieve relevant effects:

1. An increase in the average number of months of adequate household food provisioning (MAHFP)
2. An increase in the average household dietary diversity score (HDDS)

To define these indicators we use the definitions established by USAID and the FANTA project (Bilinsky et al. 2010; FAO, 2008), which the BRIDGS project adopted[7]. The Months of Adequate Household Food Provisioning (MAHFP) is constructed by asking the household the months in the past 12 months during which they did not have enough food to meet the family's needs. Three levels are defined: from three to eight months (low); nine months (intermediate); and from 10 to 12 months (high). The MAHFP for each household is calculated as: twelve months minus the total number of months out of the previous 12 months that the household was unable to meet their food needs. The Average MAHFP is calculated as the sum of the MAHFPs for all households in the sample.

The Household Dietary Diversity Score (HDDS) is a qualitative measure of food consumption that reflects household access to a variety of foods, it is also a proxy for nutrient adequacy of the diet of individuals and reflects the economic ability of a household to access a variety of foods (FAO, 2008). The dietary diversity

[7] Household food access is defined as the ability to acquire a sufficient quality and quantity of food to meet all household members' nutritional requirements for productive lives. The ability of households to obtain food from different sources, including their own production, stored food, the market, gathering, or through food transfers determines food access. However, access to food also depends on the resources available to individual household members and how they obtain these resources. Inadequate crop production, loss or decrease in income sources can all affect the ability to have adequate food consumption throughout the year.

scores consist of a simple count of food groups that a household or an individual has consumed over the preceding 24 hours[8].

Finally, we take into account three other dimensions of smallholder livelihoods on which the BRIDGES project potentially had an impact: crop yields for coffee, beans and maize; income generation from coffee production; and diversification in the sources of incomes. In fact, the project identified best management practices for coffee, maize and beans, and provided technical assistance, training and support to increase yields, efficiency, and product quality.

4.1.2. Estimating Impacts

Assessing the impact of a project means trying to determine the extent to which the project has achieved intended short- or medium term changes, and being able to attribute these changes to an intervention. However, confounding factors may contribute to the magnitude and distribution of the outcomes, and the main question of an impact evaluation is therefore one of attribution, or isolating the effect of the program from other factors and potential selection bias. In the absence of baseline data on participant and non-participant households the counterfactual or control group is defined ex-post. Several methods are available and are reviewed in various publications (Gertler et al., 2010; Khankher, 2010; de Janvry et al. 2011).

First, we estimate the probability that the household participates in the project conditional on some covariates in order to estimate the propensity score:

Participation = *f* (climate shocks in past 5 years; historical annual mean temperature; cooperative; municipality; age of the household head; education of the household head; household size; credit; farm land size; percentage of area under coffee production; total household income; number of pigs; number of chickens; number of cattle; asset wealth index; farm inputs index; market distance; electricity; number of rooms in the household; dirt floor; brick walls)

Then, we calculate the Average Treatment Effect on the Treated (ATT), which estimates the average impact of a program among those who participate in it and is useful to explicitly evaluate the effects on those for whom the intervention is actually intended. As a measure that reflects the average gains for participants, conditional on them receiving the program, it is calculated as:

$$ATT = \mathrm{E}(\Delta \mid \mathrm{X}, \mathrm{T}=1) = (\mathrm{Y}^1 - Y^0 \mid X, T=1) = E(Y^1 \mid X, T=1) - E(Y^0 \mid X, T=1)$$

where T is the treatment (BRIDGES), Y^1 is the potential outcome if the household is treated and Y^0 is the potential outcome if the individual is not-treated.

Moreover, we applied bootstrapping to estimate standard errors and calculate the statistical significance for each effect estimated. We compare the results from the PSM to a series of multiple regression models that

[8] The score used for the baseline of BRIDGES and which we use here is calculated on the following 12 food groups: cereals, roots and tubers, vegetables, fruits, meats, eggs, fish and seafood, legumes nuts and seeds, milk and milk products, oils and fats, sugar and honey, spices condiments and beverages. The food groups are aggregated with different weights following FANTA guidelines (FAO, 2008) into a single indicator (the HDDS) and take values between 0-12. Following the BRIDGES baseline study the score takes three levels: Low Level is from two to two food groups; Intermediate Level is from six to seven food groups; and High Level is from eight to 12 food groups.

estimate treatment effects by regressing the outcome on the covariates, including an indicator variable for treatment status. The comparison is reliable as the covariates group is the same in the PSM and the OLS regressions. The OLS regressions are estimated with robust errors. The following model is defined for outcome variables in the OLS regressions:

MAHFP/HDDS/ Coffee Yields/ Maize Yields/ Bean Yields = *f* (climate shocks in past 5 years; historical annual mean temperature; cooperative; municipality; age; education; sex; household size; market distance; wealth index; credit; farm land size; percentage of area under coffee production; farm inputs index)

Box 2: Propensity Score Matching

In Propensity Score Matching, the probability of participating in the treatment group, which is called the propensity score, is the basis to match participants to non-participants, so that one can likely say that they both present the same observed conditions and differ mostly because of their participation in the project. The underlying assumption is that unobserved factors do not influence participation, and an overlap in the propensity scores across treatment and control can be found. Using kernel density estimation techniques, we ensure that participants are matched with nonparticipants over a common region of the matching variables. The average treatment effect of the intervention is then calculated as the mean difference in outcomes across these two groups. There are different matching algorithms that can be used, and we report estimates from two of them. The Nearest Neighbor (NN) matching the individual from the comparison group is chosen as a matching partner for a treated individual that is closest in terms of propensity score; while Kernel matching use weighted averages of all individuals in the control group to construct the counterfactual outcome, achieving lower variance because more information is used (Caliendo and Kopeing, 2005). In Kernel matching, all treated subjects are matched with a weighted average of all controls using weights that are inversely proportional to the distance between the propensity score of treated and controls. However, if there are unobserved variables which affect assignment into treatment and the outcome variable simultaneously, the identifying assumption of unconfoundedness is violated and matching estimators are susceptible to a hidden bias. This problem can be addressed with the bounding approach proposed by Rosenbaum (2002), which represent a "worst-case" scenario where results are highly sensitive to confounding variables. With the Rosenbaum bounds we determine how strongly an unmeasured variable must influence the selection process in order to undermine the implications of matching analysis. Recent applications of this approach can be found in Aakvik (2001), DiPrete and Gangl (2004) or Caliendo, Hujer, and Thomsen (2005). The Rosenbaum bound analysis provides a value Γ, which indicates how sensitive the results are with respect to an unobserved confounder. A value of $\Gamma = 1.6$ would imply that an unobserved confounder with an explanatory power of at least 1.6 times the explanatory power of all observables X is needed to render the estimated effect statistically insignificant (at the 1% significance level).

4.2. Limitations of the IA Study

Some limitations affect our analysis: the data were not collected for the specific purpose of evaluating the BRIDGES project, but they nonetheless provide an adequate database containing information on both participating and non-participating households, with appropriate information on the main outcomes we want to measure. On the other side, the data only allow us to look at food security measures, yields and income diversification, while an important part of the impact pathway of the project based on the saving groups and commercial activities such as honey production cannot be evaluated for lack of data on these dimensions.

Moreover, the sampling strategy may be biased by the way technicians from the cooperatives select participating household, even when this is done within an adequate sampling framework. We use robust measures and sensitivity analysis to address this problem.

On the other side, the treatment variable is self-reported by sampled households, which might mean that some households have not reported their participation because they did not recall the name of the project or for other reasons. Eventual spillover effects of participation in trainings and eventually the fact that non-participating households might have benefitted from participating in some trainings cannot be accounted for with the data at hand.

Another important issue to take into account is the initial selection of households for project participation: CRS had established a number of participating household per country and cooperative at the beginning of the project. Then, each cooperative decides which associates will participate, given the number of people they had assigned: the cooperative coordinators chose participating households according to criteria established by CRS, which focus on smallholders farmers vulnerable to food insecurity (in this case measured by income) and being a participant of one of the three cooperatives. Because there is no material or clear record of this selection procedure, selection on unobservables might be a problem for our data and that is why in our analysis we compare results from different models and apply a sensitivity analysis based on Rosenbaum's bounds (see Box 2).

An interesting hypothesis would have been to test how the intensity of implementation varied across beneficiaries: some participating more in trainings, some engaging in specific productive activities, some accessing credit and so on. Project data confirm that not all treated farmers received or participated in all activities which might have led or not to impacts on food security or any other outcomes, but the data collected do not allow to analyze heterogeneous treatment effects.

4.3. Descriptive Results

In the following paragraphs we discuss the main findings based on our sample in terms of socio-economic characteristics, food security, and agricultural production, in order to prepare the discussion on the results of the econometric models.

4.3.1. Socio-economic Characteristics

In terms of main socio-economic characteristics participants and non-participants of the BRIDGES project do not appear to differ significantly. Average household size is a little less than four members, with relatively young households for rural areas as the household heads' age is 48 years on average. About a fourth ofthese families are headed by women.

TABLE 4: DEMOGRAPHIC CHARACTERISTICS

	Non Participants				**Participants**			
Variable	**n**	**Mean**	**S.D.**	**Median**	**n**	**Mean**	**S.D.**	**Median**
Number of household members	317	3.86	2.38	4	300	3.69	2.61	4
Years of education (HHH)	317	4.45	3.74	4	300	4.29	4.04	3
Age (HHH)	317	48.58	14.6	47	300	47.49	13.28	46

Sex (HHH)		Percent		Percent
Male	243	76.66%	240	80%
Female	74	23.34%	60	20%

The CUP study obtained similar average data. Nicaraguan society has experienced a development marked by civil war (1979-1990), climatic shocks, and the effects of different policies. During the war, migration from rural areas intensified, but when it was over many migrants and exiles returned, putting pressure on natural resources especially in Northern departments. Household heads had low education levels, an issue which only in recent years is being addressed by adult literacy programs. In the areas where our study is based, in order for children to attend secondary school they have to go to department main cities. Households located in Telpaneca have better access to cities, followed by San Juan del Rio Coco and finally Quilali, which is the study area further away. While regular, transport to other communities is packed with students, adults, animals, and products.

In terms of household assets, most households possess a radio and mobile phones, while only half have a television considering that lack of electricity connection is an issue in many rural areas, a third possess transport means such as a bicycle or motorcycle, while only about 40 households own a car. Interestingly, 15% of households report the installation of a solar panel, a result of a government intervention
In terms of productive assets, most households possess general toolkits and knapsack sprayers for input application. Also, given that all households are coffee producers, two thirds of them own coffee pulpers and filtering boxes, but fewer have wet coffee processing and less than thirty farmers have irrigation.

The household assets and dwelling variables are applied in the construction of a household wealth index through a Principal Component Analysis. The wealth index includes the category corresponding to the highest level of wealth for each variable: electricity in the dwelling, sewerage system in the dwelling, number of rooms excluding kitchen and bathrooms, floor type, walls type, motorcycle, car, computer, refrigerator, and sound system. Once computed the wealth index is divided in quintiles and treated as a categorical variable. Likewise, an index of farm inputs is constructed on the following variables: coffee pulper, wet coffee processing, silos, filter box (zaranda), knapsack, water pump, warehouse, toolkit, plastic and metal barrels.

TABLE 5: ASSETS AND DWELLING CHARACTERISTICS

Freq.	Percent	Productive Assets	Freq.	Percent	Dwelling Characteristics	Freq.	Percent	Household Assets
21	3%	Irrigation pump	140	22.69%	Piped water	193	31%	Bicycle
7	1%	Irrigation system	362	58.67%	Electricity	153	25%	Motorcycle
420	68%	Coffee Pulper Machine			**Walls**	43	7%	Car
178	29%	Wet coffee processing	101	16.37%	Bricks	36	6%	Computer
233	38%	Silos	496	80.39%	Mud	85	14%	Refrigerator
466	76%	Chain pump	2	0.32%	Rammed earth	455	74%	Radio
499	81%	Hand bomb	18	2.92%	Wood	81	13%	Sound equipment
62	10%	Water pump			**Floor**	307	50%	Tv
21	3%	Coffee dry area	397	64.34%	Dirt	527	85%	Cellphone
194	31%	Warehouse supplies	3	0.49%	Wood	93	15%	Solar panel
7	1%	Honey Extractor	1	0.16%	Mud bricks	208	34%	Iron
495	80%	Tools kit	192	31.12%	Tiled floor	69	11%	Blender
332	54%	Plastic barrel	5	0.81%	Cement bricks			

181	29%	Metallic barrel	19	3.08%	Mosaic or ceramics
			2.27		Average nr of rooms

We also calculate the probability of falling under the indigence line and the probability of falling under the poverty line, which are calculated according to the PPI indicator (Schreiner, 2013). The PPI is constructed on ten questions, using a weighting given by its designers, which allows estimating the probability of falling under the poverty line based on household size, education, dwelling characteristics and basic assets. The national line for indigence corresponds to USD 1.51 per day per person and USD 1.88 for the poverty national line.

About 40% of both participants and non-participants can be categorized as likely falling under the national poverty line, and as much as 9-10% of households under the indigence line, with one percentage point higher probability for households who participate in BRIDGES. The project was in fact targeted at poor farmers. Positive impacts from the project would therefore contribute to improve livelihoods of some of the poorest members of Nicaraguan society, which are also the most vulnerable to climate change and have fewer options for adaptation.

TABLE 6: PROBABILITY OF FALLING UNDER THE POVERTY LINES

Variable	TOTAL						NON PARTICIPANTS						PARTICIPANTS					
	n	Mean	S.D.	Min	Mdn	Max	n	Mean	S.D.	Min	Mdn	Max	n	Mean	S.D.	Min	Mdn	Max
Probability of falling under the indigence line	617	9.62	11.8	0	4.1	61.8	317	10.17	12.73	0	4.1	61.8	300	9.04	10.72	0	4.1	61.8
Probability of falling under poverty line	617	42.44	26.54	0	40.4	97.6	317	43.17	26.74	0	40.4	97.6	300	41.66	26.34	0	40.4	97.6

4.3.2. Food Security

As defined in the methodology section, food security can be measured in different ways and here we focus on measures of economic access to food and access to a variety of foods. We look at the Months of Adequate Food Provision (MAHFP) indicator and the Household Dietary Diversity Score (HDDS), but also at coping strategies and another standard measure applied in Latin American countries, the Latin American & Caribbean Food Security Access Scale (ELCSA) (FAO, 2012). The ELCSA is calculated on 8questions about situations that lead the families and adults to food insecurity and 7 questions on situations that lead to food insecurity for people younger than 18.

TABLE 7: MONTHS OF ADEQUATE FOOD PROVISION (MAHFP) AND HOUSEHOLD DIETARY DIVERSITY SCORE (HDDS)

Variable	TOTAL						NON PARTICIPANTS						PARTICIPANTS					
	n	Mean	S.D.	Min	Mdn	Max	n	Mean	S.D.	Min	Mdn	Max	n	Mean	S.D.	Min	Mdn	Max
MAHFP	617	10.06	1.37	6	10	12	317	9.8	1.34	6	10	12	300	10.33	1.35	6	10	12
HDDS	617	6.85	1.7	0	7	12	317	6.74	1.83	0	7	11	300	6.96	1.55	0	7	12

In terms of the MAHFP the average for the sample is about 10 months of adequate food provision, lower for non-participants than participants on average (Table 7). This result is similar to the one that CRS finds in its final report for the BRIDGES project, where these data are collected comparing the baseline data of beneficiaries in 2011 to the same data collected in 2014. In the CRS report, the average number of MAHFP is 9,9 months, which shows an increase against the baseline figure 0.1 months (CRS, 2014b).

In fact when we look at the different levels of achievement we find that a statistically significant lower percentage of beneficiary families experience a low level of food provision (3-8 months) compared to non-beneficiaries. On the other side, a significantly higher percentage of participant families have a high level of food provision (10-12) months as opposed to non-participants. This means that among those who participated in BRIDGES, only 4% experience a low level of food provision adequacy, while about 66% have 10 to 12 months of adequate provision. The activities undertaken by BRIDGES included introduction of crops in homegardens, and training of project participants in income generating activities, good governance, enterprise, water resources, and health and nutrition.

TABLE 8: LEVELS OF ACHIEVEMENTS IN MAHFP AND HDDS

		MAHFP					HDDS					
		Chi 2	**Non participants**		**Participants**			**Chi 2**	**Non participants**		**Participants**	
			Freq.	Percent	Freq.	Percent			Freq.	Percent	Freq.	Percent
Low level	3-8 Months	***	41	13%	13	4%	<6 Food groups	***	74	23%	45	15%
Intermediate Level	9 Months		101	32%	89	30%	6-7 Food groups		146	46%	148	49%
High level	10-12 Months	***	175	55%	198	66%	8-12 Food groups		97	31%	107	36%

*** p<0.01, ** p<0.05, * p<0.1

Concerning household dietary diversity the HDDS (which takes values from 0 to 12) is higher for project participants but it is only a 0.3 points difference. However, at least for the lowest level of dietary diversity (defined as consumption of less than 6 food groups) there is a statistically significant difference between participants and others: only 15% of them report a low level of HDDS compared to 23% of non-participants. However, only 31% of non-participant households and 36% of participants achieved food security in terms of dietary diversity, which means that this is dimension on which much investment is still needed. Even when we take into account the Latin American and Caribbean Food Security Scale this significant difference persists: among BRIDGES participants a lower percentage of households experiences severe or moderate insecurity (Table 9).

TABLE 9: LATIN AMERICAN AND CARIBBEAN FOOD SECURITY SCALE

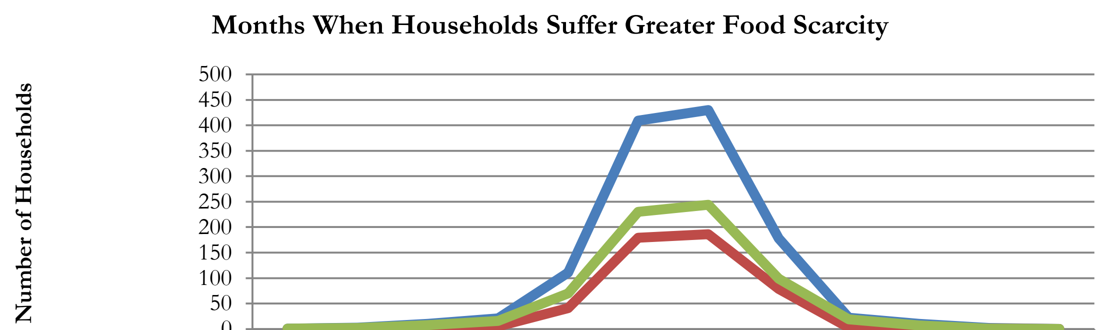
Latin American and Caribbean Food Security Scale							
Food Security Level	**Chi2**	**Total**		**Non Participants**		**Participants**	
		Number of households	**Percent**	**Number of households**	**Percent**	**Number of households**	**Percent**
Severe insecurity	**	55	8.91	36	11.36	19	6.33
Moderate insecurity	**	254	41.17	149	47	105	35
Slight uncertainty	***	268	43.44	116	36.59	152	50.67
Security		40	6.48	16	5.05	24	8

*** p<0.01, ** p<0.05, * p<0.1

When we look at seasonal patterns we find out that the months in which more households are suffering from inadequate food provision are concentrated in the June, July and August (Figure 3), which is also confirmed in the CRS report where more than 50% of the families still have a scarcity of food in these same months. During these months food reserves decrease before the first harvest (*primera*) that starts in late August, while the income from coffee marketing gets thinner as harvesting and selling happens in January/February.

To cover their needs during these months many producers request loans to have sufficient money to buy food, often offering part of their upcoming coffee harvest as collateral (Baca et al., 2013b). Many small-scale producers are entangled in a debt trap where, after being paid for the coffee harvest, money only lasts for a few months and then families look for loans for food, health, education and the upcoming harvest. If the harvest does not cover the value of the loan then the debt grows year by year until a good harvest or good prices arrive.

FIGURE 4: MONTHS OF HIGHER FOOD SCARCITY



	January	February	March	April	May	June	July	August	September	October	November	December
Total	1	3	10	21	111	409	430	178	22	10	2	0
Participants	0	1	2	5	41	179	186	79	3	3	1	0
Non Participants	1	2	8	16	70	230	244	99	19	7	1	0

As the data show, requiring a loan is the main coping strategy of households during months of lower food provision. Interestingly, a statistically significantly higher number of BRIDGES beneficiaries requests loans from cooperatives (a third of them) compared to non-participants, a significantly higher number of which has requested loans from moneylenders (Table 10). Cooperatives provide lower interest rates and generally short term conditions (6-10 months). However few households are requesting money from this type of actors, the interest rates they provide is strongly higher compared to those provided by cooperatives. Moreover, there is higher risk involved in the transaction with moneylenders, who operate outside of formal markets. This significant difference for project participants in reaching to cooperatives to loan money might be explained by the creation and promotion of lending mechanism by the cooperatives within the BRIDGES project. While the database on which this study is based does not allow further inquiry on the savings groups, CRS' final report shows that 34 out of 64 savings groups formed in Nicaragua have graduated and saved US$26,293 during the 2014 fiscal year (CRS, 2014b).

Other coping strategies that are being implemented include selling or eating some of their animals; using up own savings; requesting loans from financial institutions; and increasing working hours of household members. Temporary migration is a strategy only adopted by fewer households, but a symptom of high vulnerability because migration is a less preferred option (Baca et al., 2013b).

TABLE 10: COPING STRATEGIES TO CONFRONT FOOD INSECURITY

Coping Strategies	Non Participants Yes	Freq.	No	Freq.	Participants Yes	Freq.	No	Freq.	Chi2
They requested a loan from a cooperative	24.29	77	75.71	240	33.18	100	66.82	200	**
They sold or ate some of their animals	18.21	58	81.79	259	17.97	54	82.03	246	
They used their savings	7.5	24	92.5	293	11.62	35	88.38	265	
Members increased working hours	9.29	29	90.71	288	9.68	29	90.32	271	
They requested a loan from a financial institution	6.07	19	93.93	298	9.68	29	90.32	271	
They asked help from family or friends	5.36	17	94.64	300	7.83	23	92.17	277	
Some member who did not work before had to work	10.71	34	89.29	283	6.45	19	93.55	281	
They sold some of their assets	5	16	95	301	5.07	15	94.93	285	
They asked for a loan to a savings group	1.43	5	98.57	312	4.15	12	95.85	288	
They requested a loan from a moneylender	8.21	26	91.79	291	4.15	12	95.85	288	**
Some member temporarily migrated	3.21	10	96.79	307	2.76	8	97.24	292	
Some children had to work	0	0	100	317	0.92	3	99.08	297	
They sold part of their land	1.07	3	98.93	314	0.46	1	99.54	299	
They enrolled in a government program	1.43	5	98.57	312	0	0	100	300	
They requested a loan from ONGs	1.07	3	98.93	314	0	0	100	300	

*** p<0.01, ** p<0.05, * p<0.1

When we look at household consumption of different food groups in the previous 24 hours (HDDS), we find that most families consume cereals, mainly maize and rice, with oils and fats and sugar, as part of the main diet and basic preparations. While non-participants seem to consume more roots and vegetables, BRIDGES beneficiaries appear to consume a significantly higher amount of legumes and nuts, which were in fact targeted by the intervention, especially beans. The project provided training and technical assistance for the sowing and management of maize and beans, apart from activities in homegardens. Moreover, higher percentage of participating households consumes protein food groups such as eggs, milk and dairy, which might be a result of higher incomes or higher staple production that liberates income for other products. This is relevant in terms of food security especially considering that these are the types of foods that families tend to consume less during their months of food scarcity, and it is an indicator of the economic ability of households to access food. In fact, food that is unavailable during months of food shortages mostly includes animal products such as meat, milk, eggs or fish. Increasing household dietary diversity is also a process that might be more difficult to measure in the short-term as it is associated with long-term income changes. However, the strong prevalence of maize, rice and beans, on which food security is based in the traditional diet, shows that there is still need for further work on diet diversification.

TABLE 11: CONSUMPTION OF DIFFERENT FOOD GROUPS

Food Group	Total Freq.	Total Percent	Non Participants Freq.	Non Participants Percent	Participants Freq.	Participants Percent	Pearson Chi2
Cereal	601	97%	306	97%	295	98%	
Roots	266	43%	152	48%	114	38%	**
Vegetables	132	21%	77	24%	55	18%	**

Fruits	267	43%	145	46%	122	41%	
Meat, chicken	110	18%	56	18%	54	18%	
Eggs	384	62%	182	57%	202	67%	**
Fish, see food	4	1%	1	0%	3	1%	
Legumes and nuts	500	81%	244	77%	256	85%	***
Milk and dairy products	182	29%	72	23%	110	37%	***
Oils and fats	570	92%	282	89%	288	96%	***
Sugar and honey	604	98%	308	97%	296	99%	
Other	604	98%	311	98%	293	98%	

*** p<0.01, ** p<0.05, * p<0.1

4.3.3. Agriculture

Following the results of the long-term suitability of different crops in the project areas, activities within BRIDGES provided some technical assistance to improve coffee production, but given the focus on diversification, improvements in maize and bean cultivation were prioritized, with some development of banana and honey value chains, which especially in the case of banana encountered difficulties to take off as aforementioned. In this paragraph we show that there are some significant differences in production between BRIDGES participants and non-beneficiaries, but we do not know how much of this difference, if any, can be attributed to training and technical assistance received by technicians of the cooperatives and by farmers. In Nicaragua there are many interventions promoting agricultural training and this makes it hard to assess the marginal contribution of a project and whether this marginal contribution generated new impacts. However, we can nonetheless derive interesting insights. As the data are referred to the period May 2013-Abril 2014 it is important to mention that in 2014 coffee yields fell 16% and the price of coffee fell by 37% compared to the baseline figure at the project level (CRS, 2014b).

Production

As shown in Table 12, all producers in the sample grow coffee, as this is one of the criteria for the baseline collected for the R2R project. These data do not include ten households from the Quilali department who participated in BRIDGES and reported more than 4 tons per ha per year of bean yields. As this is a significant outlier value for the area, we exclude them from the analysis.

Average coffee area is about 2 hectares, slightly higher in Quilali municipality and lower in Telpaneca. Coffee yields per ha are also higher in Quilali and San Juan del Rio Coco, with a significant difference compared to Telpaneca. In interpreting these data, one has to bear in mind that climate conditions in Telpaneca differ from the other municipalities due to its location in the dry corridor; Quilali has different soils; and San Juan del Rio Coco has high humidity levels during coffee harvest despite altitude (400-1100 masl), which makes coffee drying difficult. The area has also been strongly affected by rust. Yearly coffee income in these two communities is therefore higher given areas and yields, and while Quilali producers sell significantly larger quantities of coffee, they receive a lower price. Access to markets from Quilali is more difficult than for the other areas, which can partially explain lower producer prices, however the area has a very dynamic internal market. Lower producer prices might be explained by the presence of many producers in the area and by higher intermediary costs to reach the communities.

Producers sampled also use a significant share of coffee production for self-consumption, however they usually consume low quality coffee, keeping the high quality one for the market.

Maize is the staple food of the Mesoamerican diet, and while resistant to increases in temperature, it is subject to water stress, which means that by 2050 it will be most affected in areas where climate is drier and between the months of May and August, when precipitation is lower (Läderach et al., 2012). As shown in our data, corn production in the departments of Nueva Segovia and Madriz is in large part for self-consumption and is carried out on small plots of about 1 ha. Average maize yields are significantly higher in Quilali than in the other municipalities, and in fact a larger part of the harvest is sold, given the higher product availability. In Telpaneca, apparently due to significantly lower yields and a higher proportion of maize used for self-consumption the yearly income received from maize is very low.

Bean prices and demand are good and increasing in Nicaragua, however projected climate change might reduce suitability of bean production in low altitude areas due to an increase of temperatures, and in intermediate zones due to lower precipitation (Läderach et al., 2012).Our data show that beans are cultivated on small 1 ha plots and the average production is lower in Telpaneca. Compared to the latter, average yield per ha is three times higher in Quilali, where a large part of the harvest is marketed, providing a significant yearly income, higher than the one received by selling maize. Self-consumption in Quilali is also significantly higher than in the other municipalities given higher productivity.

Quilali and San Juan del Rio Coco are municipalities with severe levels of poverty and are also the ones projected for higher loss of suitability for coffee production by 2050, which will instead be less intense in Telpaneca. The results form the CUP project showed that where coffee strongly loses suitability, the annual crops that gain suitability are maize (76%) and beans (93%). Where coffee loses little suitability, maize and beans gain 100% suitability (Läderach et al., 2012). The importance of coffee in these areas is clear from the survey data and shows that adaptive practices, such as the ones started by BRIDGES focusing on maize and beans, are crucial and should be part of wider efforts supported at the national level.

TABLE 12: BEAN, MAIZE AND COFFEE PRODUCTION

	Variable	Quilali			San Juan del Rio Coco			Telpaneca		
		Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Beans	Beans Area (Has)	28	1.1	0.6	85	1.04	0.8	64	0.8	0.5
	Beans income (USD)	28	349.6	530.8	85	233.7	455.5	64	63.8	115.3
	Beans Yields (Kg/Ha)	28	1067.0	642.2	85	884.0	424.5	64	655.8	448.9
	Price for kg of beans (USD)	18	0.5	0.1	53	0.5	0.1	31	0.4	0.1
	Bean production (Kg/year)	28	1188.4	1034.5	85	903.7	872.6	64	463.7	339.0
	Beans Sales (Kg/year)	28	683.9	963.8	85	441.5	780.1	64	143.8	236.6
	Beans for self-consumption (Kg/year)	28	504.5	511.9	85	462.2	283.5	64	319.9	218.1
Maize	Maize Area (Has)	44	1.0	0.7	117	1.0	0.5	82	0.9	0.5
	Maize Income (USD)	44	179.3	399.2	117	89.9	213.3	82	35.9	92.2
	Maize Yields (Kg/Ha)	44	2659.3	1239.3	117	1506.6	747.7	82	1003.5	753.6
	Price for Kg of Maize (USD)	19	0.2	0.1	46	0.2	0.1	19	0.2	0.1
	Maize production (Kg/year)	44	2680.7	2926.0	117	1559.8	1253.8	82	890.5	857.3
	Maize Sales (Kg/year)	44	1000.0	2425.0	117	449.6	1022.6	82	198.5	547.6
	Maize for self-consumption (Kg/year)	44	1680.7	1122.8	117	1110.3	652.9	82	692.1	523.5
ffe	Coffee Area (Has)	101	2.2	0.9	341	1.9	0.9	146	1.6	0.9

Coffee income (USD)	101	2215.6	2038.0	341	1655.6	1661.1	146	862.0	1164.4
Coffee Yields (Kg/Ha)	101	593.1	408.9	341	410.1	301.9	146	231.0	205.0
Price for Kg of Coffee (USD)	99	1.9	0.3	337	2.2	0.4	135	2.4	0.5
Coffee production (Kg/year)	101	1299.0	1133.8	341	816.1	799.5	146	402.6	529.4
Coffee Sales (Kg/year)	101	1199.4	1097.1	341	759.5	760.6	146	359.3	498.9
Coffee for self-consumption (Kg/year)	101	99.6	81.6	341	56.6	78.2	146	43.3	51.5

In terms of other crops managed by surveyed households, banana, maize and beans are cultivated by more than 30% of households, while other crops are only cultivated by less than 10% of respondents. There appears to be a statistically significant difference in the percentage of households growing maize and beans who participate in BRIDGES (47% and 37% respectively) compared to non-participants (30% and 31% respectively).

Most families possess poultry, however 5% more families in BRIDGES have them compared to non-participants, which might also be part of egg consumption which was found significantly higher... It also seems that more BRIDGES participants have pigs and cows compared to non-participants, possibly a result of improved incomes. The difference in households owning pigs is especially significant.

TABLE 13: LIVESTOCK AND OTHER CROPS CULTIVATED BY SURVEYED HOUSEHOLDS

	Total		**Not Bridges**		**Bridges**		
Livestock	Freq.	Percent	Freq.	Percent	Freq.	Percent	***Chi2***
Poultry	495	80%	238	75.10%	257	85.70%	***
Pigs	178	29%	66	20.80%	112	37.30%	***
Cows	53	9%	21	6.60%	32	10.70%	**
Calves	42	7%	14	4.40%	28	9.30%	**
Honeybees	34	6%	15	4.70%	19	6.30%	
Bulls	16	3%	7	2.20%	9	3.00%	
Cultivated Plots							
Banana	469	76%	246	77.60%	223	74.30%	
Maize	249	40%	108	34.10%	141	47.00%	***
Beans	194	31%	83	26.20%	111	37.00%	***
Orange	47	8%	26	8.20%	21	7.00%	
Plantain	36	6%	16	5.00%	20	6.70%	
Sweet potato	2	0%	0	0.00%	2	0.70%	
Vegetables	1	0%	0	0.00%	1	0.30%	
Avocado	2	0%	2	0.60%	0	0.00%	
Malanga	1	0%	1	0.30%	0	0.00%	
Mandarin	2	0%	2	0.60%	0	0.00%	

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Agricultural Practices

Table 14 gives an overview of the agricultural practices implemented in the study area. Practices used by more than 50% of households surveyed include coffee shade management, contour planting, pruning management and live barriers. Significant differences already emerge between BRIDGES participants and non: while contour planting is applied by half of beneficiary households, pruning management is more common among non-participants as 70% of them apply it. Among practices applied by 20 to 50% of producers, it is interesting to note a lower use of burning by project participants, and a higher percentage of farmers applying crop rotation, however these differences are not statistically significant. Practices applied by less than 20% of producers include minimum tillage and early harvest, which are applied by a statistically significant higher percentage of BRIDGES participants. It appears therefore that participants apply some conservation practices, and in fact these were among the practices inventoried by CIAT to improve soil and crop management. For beans, for instance, CIAT recommended and offered management instructions on a series of activities including pathogen free seed, varietal resistance, minimum tillage and crop rotation (Baca et al., 2013 – Annex 2). Respondents apply about 4 practices on average (with mean value 4.7 for participants, 4.2 for non-participants) and about 30% of participants apply 3 practices, against 26% of non-participants, while less than 10% of respondents apply five or more practices.

Few respondents answered about why they were not applying some of the practices they knew. Among non-participants, nine people gave a reason why they do not apply no burning: half of them because it is not suitable for the agronomic conditions they face. Seven non-participants said they do not use contour planting mainly because they do not know how to apply it; five of them gave the same two reasons for cleaning and classification. Among participants, nine people said they do not apply no burning because they do not know how to, while very few participants gave reasons for non applying other practices they know such as cleaning and classification, mainly in terms of lack of money. Despite this is based on very few answers it shows a need for technical assistance to apply practices farmers have heard about and a need for financial instruments to help them doing so.

Our findings in terms of practices confirm results from previous studies. Participatory workshops carried out within CUP and BRIDGES produced insight on major changes in the past twenty years: participants agreed that before the extension of coffee production was lower, as well as planting density, its cultivation was of traditional sort, and the forest was cleaned and planted bare root under the shade of native trees, such as cedro, caoba, guayabo, madero negro, níspero, areno (Baca et al., 2013). Today, tall coffee varieties such as Typica and Borboun have been replaced by low varieties, mainly Caturra. Pests and disease control was less labor and input intensive, while today here is more need for preventive and control measures to avoid that quality and production are affected. Currently, coffee production is both traditional and commercial, and shade management includes some native and introduced species. In traditional systems, there is conservation of biodiversity, while in commercial systems shade is provided by Inga species. These provide good nitrogen fixation, erosion and weed control, but have been affected by leaf damaging pests and diseases, putting at risk coffee cultivation due to monocrop shading. There is some use of live barriers for soil and water conservation, as well as the selective management of weed, however preventive measures and monitoring of pests is not common in Nicaragua. Organic fertilizer application seems widespread, while handling tissues, restocking or renovation with new coffee trees, practices for soil and water conservation, including terracing, contour planting and ditches are traditional practices which are only maintained by few producers.

TABLE 14: AGRICULTURAL PRACTICES USED BY HOUSEHOLDS SURVEYED

Agricultural Practices									
	No Participants				Participants				
	Yes (Freq.)	Yes (%)	No (Freq.)	No(%)	Yes (Freq.)	Yes (%)	No (Freq.)	No(%)	Chi 2

Coffee shade management	197	62%	119	38%	199	66%	100	33%	
Pruning Management	219	69%	97	31%	172	57%	127	42%	***
Live barriers	134	42%	182	57%	141	47%	158	53%	
Contour planting	101	32%	215	68%	138	46%	161	54%	***
Cleaning and Classification	115	36%	201	63%	122	41%	177	59%	
No burning	130	41%	186	59%	106	35%	193	64%	
Cover Management	80	25%	236	74%	60	20%	239	80%	
Crop Rotation	44	14%	272	86%	55	18%	244	81%	
Protecting water sources	46	15%	270	85%	54	18%	245	82%	
Minimum tillage	32	10%	284	90%	44	15%	255	85%	**
Germination tests	30	9%	286	90%	30	10%	269	90%	
Inoculants	30	9%	286	90%	30	10%	269	90%	
Sampling pests / diseases	30	9%	286	90%	24	8%	275	92%	
Early Harvest	2	1%	314	99%	11	4%	288	96%	***
Safe use and management of pesticide and pests	16	5%	300	95%	9	3%	290	97%	
Green Fertilizer	6	2%	310	98%	6	2%	293	98%	
Farm's plans	6	2%	310	98%	5	2%	294	98%	
Construction of water storage systems	6	2%	310	98%	2	1%	297	99%	
Sampling of pests and diseases	1	0%	315	99%	2	1%	297	99%	
Economics analysis of crops	0	0%	316	100%	1	0%	298	99%	
Crop Nutrition	1	0%	315	99%	0	0%	299	100%	

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

When cross validating CRS reports with our database we find that 224 people in our sample participated in various type of trainings. Table 16 shows that 37% of them participated in one training on banana management and about 26% in a training on banana production in general; about 30% participated in a training on sweet potato and about 30% in a training on bean sowing; about 26% attended a training on the management of agroforestry systems. Overall, about 25% of participants participated in three different trainings; 20% in two trainings; 18% in four trainings; 14% in one training; 12% in five trainings; and 9% in 6 trainings. Four people participated in seven trainings and one person in 9.

Specifically accounting for trainings between May 2013 and April 2014, no more than 40% of households interviewed received training on agricultural practices (Table 15). Most people trained received extension on pest and disease management and coffee production, however significantly more non-participants have been trained in pest and disease management, while more BRIDGES participants received training in coffee management and production. Extension or training on other practices have targeted fewer farmers, in fact little less than 10% received soil and water conservation practices. Finally, significantly more BRIDGES participants than non-beneficiaries have received extension on farm plans and on post-harvest practices for beans (but very few cases). Post-harvest management was one of the main issues identified by CIAT in the CUP project. However, since cooperatives reactivated their activities about 10-15 years ago, they have attracted several development projects, while the private sector also provides technical assistance. Overall, about 50% of small and medium producers have access to yearly technical assistance.

TABLE 15: TRAININGS CARRIED OUT IN BRIDGES

Beans	Beans (postrera)		Beans (primera)		Beans		Bean Sowing		Support to Bean Sowing	
	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating
	1	23	1	20	1	28	1	69	1	12
	2	22	2	2					2	1
			3	1						
Maize	Maize (primera)		Maize		Maize sowing		Support to Maize sowing			
	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating		
	1	34	1	27	1	26	1	24		
	2	9					2	1		
Homegardens and Sweet Potato	Homegardens		Support to sowing in homegardens		Sweet potato (Camote) sowing		Sweet potato (Camote)			
	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating		
	1	22	1	17	1	65	1	13		
Coffee and Agroforestry	Coffee Management		Coffee rehabilitation		Management of Agroforestry systems		Agroforestry			
	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating		
	1	10	1	9	1	59	1	44		
	2	1								
Banana and Honey	Musaceas		Sowing of Musaceas		Support to sowing of Musaceas		Hives			
	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating	Nr of trainings received	Nr of people participating		
	1	57	1	84	1	8	1	12		
							2	2		

TABLE 16: PRACTICES ON WHICH THE HOUSEHOLDS RECEIVED EXTENSION OR TRAINING IN 2014

Practices	Total		Non Participants		Participants		Chi2
	Freq.	Percent	Freq.	Percent	Freq.	Percent	
Pest and diseases management	226	36.60%	123	38.80%	103	34.30%	**
Soil and water conservation practices	51	8.30%	26	8.20%	25	8.30%	
Coffee production and management	192	31.10%	84	26.50%	108	36.00%	**
Basic grains production	5	0.80%	1	0.30%	4	1.30%	
Fram plans	17	2.80%	1	0.30%	16	5.30%	***
Coffee post-harvest practices	12	1.90%	6	1.90%	6	2.00%	
Basic grains post-harvest practices	3	0.50%	0	0.00%	3	1.00%	**
Irrigation and water management	0	0.00%	0	0.00%	0	0.00%	
Collective action	14	2.30%	4	1.30%	10	3.30%	
Agricultural research	1	0.20%	0	0.00%	1	0.30%	

*** p<0.01, ** p<0.05, * p<0.1

Our descriptive analysis mirrors findings from the *Thin Months* report, which, despite being based on a very small sample, showed that producers especially favor technical assistance and that demand for it significantly exceeds supply. Requested trainings include extension-type consultations on coffee production practices and on-going assistance with non-coffee NGO/government sponsored projects.

Finally, lessons learned from an internal CRS report also address some limitations of the project due to lack of financial resources and technical personnel. These include the need to promote the production of organic-farm inputs for use in home gardens; using alternative methods of crop production with farmers with small landholdings (hydroponics, use of tires, etc.); promote the acquisition of postharvest infrastructure for basic grains (e.g. Silos); and promote water harvesting techniques in dry areas and conventional irrigation for the summer period, as productive activities are currently carried out during winter period. This would improve the availability of food during the dry months.

4.4. Econometric Results and Discussion

The previous descriptive analysis shows that there are some areas in which there appear to be significant difference between BRIDGES participants and non-participants. In particular, we are interested in months of adequate food provision, household dietary diversity, yields of targeted crop, income from coffee and dependence from this income, as these were among the crucial dimensions that BRIDGES set out to impact.

Table 16 provide descriptive statistics of the dependent variables used to model the effect of participating in the BRIDGES project, while Table 17 shows descriptive statistics used to define the propensity score and used as independent variables in the OLS regression. As aforementioned, we show results for both PSM and OLS in order to provide a comparison of magnitude and significance of effects of the BRIDGES project with different models and for robustness of results. All OLS regressions are calculated with robust standard errors to account for heteroscedasticity. In the Annex, we also show a comparison with different specifications of the regressions that take into account the specific distribution of the dependent variable. The sign and significance of coefficients is unchanged and therefore robust.

TABLE 17: SUMMARY STATISTICS OF THE DEPENDENT VARIABLES USED IN THE MODEL

Variable	n	Mean	S.D.	Min	Mdn	Max
MAHFP	588	10.03	1.36	6	10	12
HDDS	588	6.85	1.69	0	7	12
Maize Yields	243	1545.54	1028.03	0	1349.43	5326.7
Beans Yields	177	830.42	492.74	0	811.69	2840.91
Number of income sources	588	2.59	0.98	0	3	5
Dependency on coffee income	587	0.61	0.35	0	0.7	1

TABLE 18: DESCRIPTIVE STATISTICS OF EXPLANATORY VARIABLES USED FOR THE PROPENSITY SCORE MATCHING AND IN THE OLS REGRESSIONS (FREQUENCIES FOR DUMMIES)

Variable	Variable Label	n	Mean	S.D.	Min	Mdn	Max
Climate Shock	If the household experienced an extreme climate event in the past 5 years	588	220		0		1
Annual Mean Temperature	Annual Mean Temperature in the area where household is located (historical 1950-2000)	588	21.19	0.85	19	21.25	23.7
PRODECOOP	Household belongs to PRODECOOP cooperative	588	262		0		1
UCA SJRC	Household belongs to UCA cooperative	588	208		0		1
QUILALI	Household located in San Juan del Rio Coco	588	341		0		1
SAN JUAN DE RIO COCO	Household located in Quilali	588	102		0		1
HH head age	Age of the head of household	588	47.92	14.05	20	46	88
HH head years of education	Years of education completed by the head of household	588	4.42	3.91	0	3	18
HH size	Number of households member	588	4.64	1.95	1	4	12
Total Area Has (used)	Total area owned or managed by the household	588	3.95	4.29	0.35	2.8	32.9
% Coffee Area	Percentage of total cultivated area which is cultivated with coffee	588	0.68	0.3	0.05	0.69	1
Total incomes (US$)	Total income	588	5291.68	12828.54	0	1866.67	180000
Pigs (units)	Numer of animals	588	0.45	1.24	0	0	24
Poultry (units)	Numer of animals	588	10.07	10.75	0	8	100
Cattle (units)	Numer of animals	588	0.76	2.51	0	0	25
Quintile 2 of Wealth Index	If the household belongs to the second quintile of the wealth index	588	108		0		1
Quintile 3 of Wealth Index	If the household belongs to the third quintile of the wealth index	588	107		0		1
Quintile 4 of Wealth Index	If the household belongs to the fourth quintile of the wealth index	588	119		0		1
Quintile 5 of Wealth Index	If the household belongs to the fifth quintile of the wealth index	588	115		0		1
Distance to markets (minutes)	Distance to the main market (minutes)	588	52.26	36.06	0	45	240
Credit	If the household has obtained credit in the past year	588	383		0		1
Wet coffee processing	If the household is owner of Wet coffee processing	588	164		0		1

Silos	If the household is owner of Silos	588	219		0		1
Filter box (zaranda)	If the household is owner of zaranda	588	441		0		1
Chain pump	If the household is owner of Wet coffee processing	588	473		0		1
Warehouse supplies	If the household is owner of Warehouse supplies	588	183		0		1
Plastic barrel	If the household is owner of plastic barrel	588	316		0		1
Metallic barrel	If the household is owner of Metallic barrel	588	177		0		1
Electricity	Average nr of rooms of the household	588	2.27	1.07	0	2	6
Average nr of rooms	If the household have electricity	588	348		0		1
Mud walls	The exterior walls of the household are mud	588	377		0		1
Brick walls	The exterior walls of the household are bricks	588	96		0		1

In order to build an appropriate counterfactual, with a good common support we defined 25 dimensions that we find as key to identify underlying differences between households and therefore match project participants to comparable non-participants. These dimensions include climate variables that show long and short-term trends: annual mean temperature is calculated on WorldClim data from 1950 to 2000 matched to household georeferenced location, and if the household experienced climate shocks in the past five years that affected productivity. Climate shocks are defined as an extreme event experienced in the past five years by the households, including flooding, drought, fire, landslides or land subsidence. Location variables such as municipality and distance to the nearest market in minutes are included for site-specific effects; association to the local cooperatives is used as households have access to different services through them. Household specific variables include age and education of the household head, and size of the household, a measure of labor availability. Access to credit in the past year is specified along with a wealth index for household assets, while productive assets and dwelling characteristics take into account economic differences of the households. Finally, total area available to the household and percentage of area cultivated with coffee take into account productive strategies available and chosen by the households.

Table 18 and Table 19 show the Average Treatment Effect on the Treated and the results from OLS regressions. The results from our regressions and propensity score analyses mainly agree on the size and statistical significance of the effects of participation in BRIDGES.

In terms of the food security dimensions that BRIDGES set out to influence there is a positive impact in terms of MAHFP with different weightings and this is confirmed in the OLS and count regressions. The size of the effect is an increase in food provision of about 0.3 months approximately, meaning that participating families experience about 10 more days per year of food security. The magnitude of this effect might not seem high however considering that in the reference period there were lower coffee harvests and price drops, this is a significant change in household food security, especially within a relatively small budget project, and given the limitations of the present study. It also shows that there is more need for interventions targeted at increasing food security, as this is a crucial vulnerability of households especially during months before the harvest.

On the other side, the impact on dietary diversity is not significant in any of the specifications of the model. As shown in univariate analysis BRIDGES participants appear to consume more protein content, which is relevant especially during the months of food scarcity (July and August) when household reduce consumption of milk, meat, eggs and dairy products, however the overall variability of the HDDS does not seem to differ significantly for project participants. Taking into account that dietary diversity might be a longer term process than what can be measured in this study, learning from activities carried out in this area can guide subsequent interventions, especially considering that a new CRS project on resilience to coffee rust is about to start (*R2R*).

According to the ATT, participating in BRIDGES does not have an effect on bean yields although when applying OLS the effect is positive (230 kg/ha) and significant at the at the 5% level, but sensitive to different specifications of the model. According to participatory workshops, Nicaragua farmers perceive the production of maize and beans to be just as important for their livelihoods as the other activities. In univariate analysis in the food security section we found that participating households consumed a higher amount of legumes in 2014, which would be consistent with this result. Moreover, results from the *CUP* project showed that where coffee strongly loses suitability, the annual crops that gain suitability are maize (76%) and beans (93%). Where coffee loses little suitability, maize and beans gain 100% suitability (Läderach et al., 2012).Since 2008, the price of beans on the market has strongly increased, which incentivized farmers to invest on this crop. BRIDGES participants might have seen a favorable opportunity in the program's focus on these crops among other things. In fact, the ten outliers that were excluded from econometric analysis were all BRIDGES participants from Quilali who reported extremely high yields on beans (above 4 tons/ha).

On the other side, there is no effect for maize yields, which is an important point for reflection for subsequent interventions given the importance of maize in the local diet and the potential impacts that might also affect this crop due to climate change. We also have to keep in mind that while BRIDGES was only the latest in a series of interventions aimed at improving livelihoods of smallholder coffee farmers, three years are a very short time to devise impact.

Finally, in terms, we look at the effects of participation in BRIDGES on diversification of income sources and dependency on coffee incomes.. Participants seem to have almost one more income source as compared to non-participants, which represents an interesting and significant result for BRIDGES considering that one of its objectives was income diversification to reduce dependency on coffee incomes. In fact, it appears that participation in BRIDGES has reduced dependency on coffee incomes for beneficiary families by about 6%, a result that remains significant and of the same magnitude in all specifications of the model. While data on incomes are analyzed with caution, these are positive signs of early impacts that should be further investigated.

TABLE 19: AVERAGE TREATMENT EFFECTS ON THE TREATED

ATT effects and sensitivity analysis with Rosenbaum bounds

Variable	n	ATT		Value of gamma (Upper Bounds reported)										
		Kernel	Nearest Neighbour	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
MAHFP	588	0.319**	0.344***	0.00	0.01	0.03	0.08	0.19	0.35	0.52	0.68	0.81	0.89	0.94
HDDS	588	-0.156	-0.126	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beans Yields	177	230.696**	112.36	0.00	0.00	0.00	0.01	0.02	0.04	0.07	0.11	0.15	0.21	0.27
Maize Yields	243	343.3933**	246.68	0.02	0.05	0.10	0.19	0.30	0.42	0.55	0.66	0.75	0.83	0.88
Coffee dependency	587	-0.056442	-.0645*	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of income sources	588	0.843***	0.857***	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

TABLE 20: RESULTS FROM OLS REGRESSIONS

	OLS Regressions					
	Food Security		Crop Yields		Income	
Variable	**MAHFP**	**HDDS**	**Beans Yields (kg/h)**	**Maize Yields (kg/h)**	**Dependency on coffee income**	**Number of income sources**
Bridges	0.20*	-0.12	25.61	174.47	-0.07***	0.88***
Climate Shock	-0.43***	-0.41***	4.88	-156.31	0.05*	-0.13
Annual Mean Temperature	0.03	0.03	-33.66**	27.72	-0.05***	0.13***
PRODECOOP	0.41**	0.2	-79.76**	-27.98	-0.06	0.05
UCA SJRC	0.21	-0.85***	-77.34*	-21.06	0.06	-0.08
QUILALI	0.07	0.08	262.81***	1010.95***	0.13**	-0.17
SAN JUAN DE RIO COCO	0.15	0.18	113.40***	230.40*	0.09**	0.02
HH head age	-0.01***	-0.01	-5.83***	-9.98**	0	0
HH head years of education	0.02	0.05**	-6.06	20.55	0	-0.01
HH size	-0.08***	-0.01	-5.25	-47.3	-0.01	0.02
Total Area Has (used)	0	-0.02	4.36	9.84	0.02***	-0.02*
% Coffee Area	-0.47*	-0.03	136.59**	309.83	0.25***	-0.56***
Total incomes (US$)	0	0	0.00**	0	-0.00***	0.00**
Pigs (units)	0	0.05	8.68	41.07	0.01	-0.01
Poultry (units)	0.01	0.02***	1.44	3.61	0	0
Cattle (units)	0.05***	0.03	-8.74	29.05	-0.02***	0
Quintile 2 of Wealth Index	-0.19	0.12	-14.32	-187.37	-0.03	-0.07
Quintile 3 of Wealth Index	0.25	0.29	29.25	187.37	-0.03	0.18*
Quintile 4 of Wealth Index	0.28	0.49**	14.93	11.6	-0.05	0.22*
Quintile 5 of Wealth Index	0.36	0.97***	17.75	168.93	-0.12**	0.36**
Distance to markets (minutes)	0.00**	-0.01***	0.43	3.08*	0.00**	0
Credit	0.1	0.07	29.98	-45.63	0.07**	0.02
Wet coffee processing	0.1	0.26*	48.96	14.84	0.04	0.01
Silos	0.03	-0.03	60.62**	385.84***	0.04	-0.01
Filter box (zaranda)	-0.14	0.05	84.32***	-1.24	-0.02	0.21**
Chain pump	-0.05	0.01	39.11	-318.03*	0.10***	-0.01
Warehouse supplies	0.14	0.11	1.96	-53.21	-0.02	-0.08
Plastic barrel	0.05	-0.13	0.89	-10.4	0.01	-0.08
Metallic barrel	0.23*	-0.01	-23.18	-53.53	0.04	-0.03
Electricity	0.1	-0.37**	-67.23**	-114.9	-0.10***	0.15*
Average nr of rooms	0.14**	0.03	10.3	91.11	0.02	-0.07**
Mud walls	0.06	-0.25	-37.86	-152.51	0.05	-0.06
Brick walls	-0.1	0.01	6.55	-237.82	0.02	-0.03
constant	9.14***	6.73***	1103.78***	935.43	1.41***	0.06
Number	588	588	588	243	587	588
Chi Sqrt						
Log-Likelihood	-936.49	-1037.92	-4131.98	-1946.65	-97.77	-691.58
LRI						
AIC	1940.98	2143.84	8331.97	3961.29	263.55	1451.16

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusion

According to our analysis, the Nicaragua branch of the BRIDGES project carried out by CRS and supported by CIAT, had a positive and significant effect in at least two of its main objectives. The project focused on food security of smallholder coffee producers through the promotion of maize and bean production among other economic activities, on the creation of saving groups, and diversification of incomes. We focused on short-term impacts in terms of food security and agricultural production and income sources. The project seems to have contributed to increased months of adequate food provision by a third, potentially improved bean production and likely helped diversify income sources, contributing to reduce the dependency of households from coffee income. These are significant changes for a relatively small budget project, which focused on 800 plus producers. However, some of the initial objectives, such as increased diet diversification and promotion of the banana value chain, were not fully achieved and potentially expanded the efforts to results far too ambitious for a small project. The lessons learned from this project are nonetheless useful for other interventions with similar producers in comparable areas. Moreover, the impact pathway followed by CIAT and CRS is an example of successful research for development, where solid scientific data were taken into account for the implementation of a chain of interventions. Finally, the importance of coffee in these areas is clear, especially where the projected impacts of climate change reducing suitability for coffee production are greatest. Our results show that adaptive measures are crucial and should be part of wider efforts supported at the national level. The Nicaraguan National Adaptation Plan passed in 2013, to which CIAT contributed, is a first step towards this adaptive strategy, however more concerted and targeted efforts are needed to make the coffee sector in Nicaragua (and Mesoamerica) resilient and prepared to confront change.

References

Aakvik, A. 2001. Bounding a matching estimator: The case of a Norwegian training program. Oxford Bulletin of Economics and Statistics 63: 115–143.

Baca, M, Läderach, P, Haggar, J, Ovalle, O, Ocón, S, Gómez, L y Zelaya, C. 2011. Vulnerabilidad y estrategias de adaptación al cambio climático en los medios de vida de las familias de Nicaragua. Centro Internacional de Agricultura Tropical (CIAT), Managua, Nicaragua.

Baca, M, Läderach, P, Ocón, S, Gómez, L,Venstra, J, Carmona, S. 2013. Tecnologías alternativas para reducir la brecha de los meses flacos en los medios de vida de los pequeños productores de café en Centro América ante el Cambio climático. Centro Internacional de Agricultura Tropical (CIAT), Managua, Nicaragua.

Baca, M., Liebig, T., Caswell, M., Castro Tanzi, S., Méndez, V.E., Läderach, P., Morris B. and Aguirre, Y. 2013b. Thin Months Revisited. Final Report. December 31, 2013

Bilinsky, Paula; and Swindale, Anne. 2010. Months of Adequate Household Food Provisioning (MAHFP) for Measurement ofHousehold Food Access: Indicator Guide(v.4).Washington, D.C.: FHI 360/FANTA

Caliendo, M., R. Hujer, and S. Thomsen. 2005. The employment effects of job creation schemes in Germany. IZA Discussion Paper No. 1512. Bonn, Germany.

Caliendo, M., and S. Kopeinig. 2005. Some practical guidance for the implementation of propensity score matching. IZA Discussion Paper No. 1588. Bonn, Germany. http://ftp.iza.org/dp1588.pdf.

Caswell M; Méndez VE; Baca M; Läderach P; Liebig T; Castro-Tanzi S; Fernández M. 2014. Revisiting the "thin months" – A follow-up study on the livelihoods of Mesoamerican coffee farmers.CIAT Policy Brief No. 19. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. 6 p.

Caswell M; Méndez VE; Bacon CM. 2012.Food security and smallholder coffee production: Current issues and future directions. ARLG Policy Brief # 1.Agroecology and Rural Livelihoods Group (ARLG), University of Vermont: Burlington, VT, USA. http://www.uvm.edu/~agroecol/ CaswellEtAl_FoodSecurityCoffeeARLG%20 pb1_12.pdf

CRS. 2011. CAFE Livelihoods (Coffee Assistance for Enhanced Livelihoods) Final Report to the Howard G. Buffett Foundation

CRS. 2012. BRIDGES Annual Report: October 2011 to September 2012.

CRS. 2014a. BRIDGES Semi-Annual Report. October 2013 to March 2014

CRS. 2014b. Sixth Semi-annual and Final Report for the BRIDGES Project: "FROM SCARCITY TO ABUNDANCE". December 2014

De Janvry, A., Dunstan, A., and Sadoulet, E. 2011. Recent Advances in Impact Analysis Methods for Ex-post Impact Assessments of Agricultural Technology: Options for the CGIAR. Report prepared for the workshop: Increasing the rigor of ex-post impact assessment of agricultural research: A discussion on estimating treatment effects, organized by the CGIAR Standing Panel onImpact Assessment (SPIA), 2

October, 2010, Berkeley, California, USA. Independent Science and Partnership Council Secretariat: Rome, Italy.

DiPrete, T., and M. Gangl. 2004. Assessing bias in the estimation of causal effects: Rosenbaum bounds on matching estimators and instrumental variables estimation with imperfect instruments. Sociological Methodology 34: 271–310.

Eakin H, Tucker C, Castellanos E (2006) Responding to the coffee crisis: a pilot study of farmers' adaptations in Mexico, Guatemala and Honduras. Geogr J 172:156–171

FAO. 2012. Escala Latinoamericana y Caribeña de seguridad alimentaria (ELCSA): Manual de uso y aplicaciones. FAO Regional Office, Santiago.

FAO and Food and Nutrition Technical Assistance Project.2008. Guidelines for Measuring Household and Individual Dietary Diversity. FAO, Rome.

Fujisaka S. 2007. Coffee farmer welfare in Nicaragua, Mexico, and Guatemala.Final Research Report.International Center for Tropical Agriculture (CIAT) – Green Mountain Coffee Roasters (GMCR).

Gertler P, Martinez S, Premand P et al. (2010) Impact Evaluation in Practice. World Bank, Washington.

Khandker, S.R., Koolwal, G.B. and Samad, H.A. 2010 Handbook on impact evaluation: quantitative methods and practices. World Bank, Washington, DC.

Läderach, P., Jarvis, A. and Ramirez, J. 2008. The impact of climate change in coffe-growing regions.Taller de Adaptacion al Cambio Climatico en las Comunidades Cafetaleras de la Sierra Madre de Chiapas, 17-18 Noviembre del 2008, Tuxtla Gutierrez, Chiapas.

Läderach, P; Lundy, M; Jarvis, A; Ramírez, J; Pérez, P.E; Schepp, K and Eitzinger, A. 2010a.Predicted impact of climate change on coffee-supply chains.*In* Leal Filho, W. (ed) The Economic, social and Political Elements of Climate Change, Springer Verlag, Berlin, DE. 19 p.

Läderach, P.; Haggar, J.; Lau, C.; Eitzinger, A.; Ovalle, O.; Baca, M.; Jarvis, A.; Lundy, M. 2010b. Mesoamerican coffee: Building a climate change adaptation strategy. CIAT Policy Brief no. 2.Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. 4 p.

Läderach, P., Zelaya, C., Ovalle, O., García, S., Eitzinger, A., and Baca, M. 2012. Escenarios del Impacto del Clima Futuro en Áreas de Cultivo de Café en Nicaragua. Informe final

Lundy, M. 2011. CAFE Livelihoods Desk Review. Prepared for Catholic Relief Services. International Centre for Tropical Agriculture

Macours, K.; Premand, P.; Vakis, R.; Marcus, A. [editor]. 2012. Can small farmers protect themselves against bad weather?From evidence to policy. Washington, DC: World Bank.

Rosenbaum, P.R., Rubin, D.B., 1983. The central role of the propensity score in observational studies for causal effects. Biometrika 70 (1), 41.

Schreiner, M. 2013. Un Índice Sencillo de Calificación de Pobreza en Nicaragua. 2013. Available at: microfinance.com/#Nicaragua

ANNEX I – Econometric Results

Propensity Score Matching

Mean comparison of matching variables (Frequencies for Dummies)*

Variable	Non Participants	Participants
Climate Shock	129	94
Annual Mean Temperature	21.09	21.28
PRODECOOP	107	160
UCA SJRC	145	72
QUILALI	32	70
SAN JUAN DE RIO COCO	188	166
HH head age	48.45	47.47
HH head years of education	4.44	4.30
HH size	4.68	4.65
Total Area Has (used)	3.21	4.71
% Coffee Area	0.73	0.63
Total incomes (US$)	5288.05	5323.73
Pigs (units)	0.38	0.51
Poultry (units)	7.79	12.4
Cattle (units)	0.56	0.93
Quintile 2 of Wealth Index	63	54
Quintile 3 of Wealth Index	57	66
Quintile 4 of Wealth Index	70	50
Quintile 5 of Wealth Index	61	60
Distance to markets (minutes)	48.55	56.75
Credit	177	215
Wet coffee processing		
Silos	87	85
Filter box (zaranda)	95	130
Chain pump	219	237
Warehouse supplies	247	245
Plastic barrel	72	116
Metallic barrel	171	159
Electricity	81	100
Average nr of rooms	205	153
Mud walls	2.19	2.37
Brick walls	250	239
Climate Shock	40	61

*The ten outliers are excluded from calculations

Parameter estimates of logit-model for program participation

Variable	Marginal Effect
Climate Shock	-0.139***
Annual Mean Temperature	0.042
PRODECOOP	0.025
UCA SJRC	-0.297***
QUILALI	-0.045
SAN JUAN DE RIO COCO	-0.017
HH head age	0.000
HH head years of education	-0.003
HH size	-0.008
Total Area Has (used)	0.004
% Coffee Area	-0.198*
Total incomes (US$)	0.000
Pigs (units)	0.008
Poultry (units)	0.004*
Cattle (units)	-0.007
Quintile 2 of Wealth Index	-0.060
Quintile 3 of Wealth Index	-0.011
Quintile 4 of Wealth Index	-0.077
Quintile 5 of Wealth Index	-0.030
Distance to markets (minutes)	0.001
Credit	0.158***
Wet coffee processing	-0.066
Silos	0.014
Filter box (zaranda)	0.067
Chain pump	-0.012
Warehouse supplies	0.168***
Plastic barrel	0.063
Metallic barrel	0.066
Electricity	0.031
Average nr of rooms	0.016
Mud walls	-0.087
Brick walls	-0.088
Number	588
Chi Sqrt	119.938
Log-Likel	-347.30
LRI	0.147261
AIC	760.522

*** p<0.01, ** p<0.05, * p<0.1

COMMON SUPPORT

Inferior bound, the number of treated and the number of controls for each block in the common support

Blocks	Non participants	Participants	Total
0.084	43	12	55
0.2	122	48	170
0.4	82	82	164
0.6	47	89	136

0.8	3	53	56
Total	297	284	581

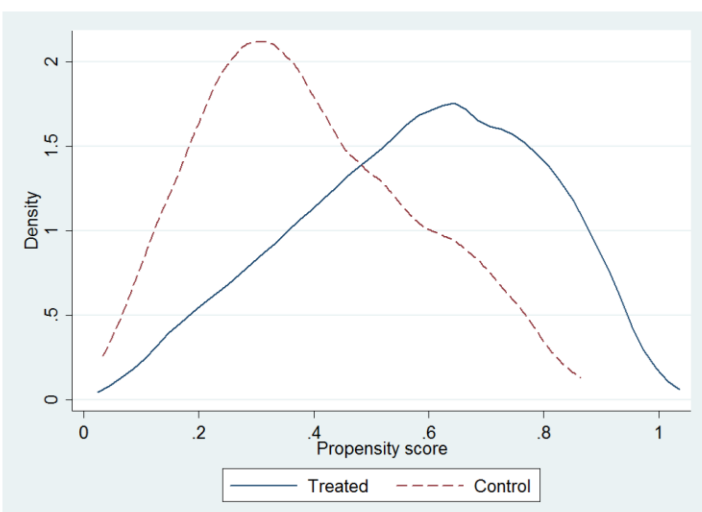
Description of the estimated propensity score in region of common support				
	Percentiles	**Smallest**		
1%	0.1193961	0.0836208		
5%	0.1593119	0.0980223		
10%	0.2041601	0.1044351	**Obs**	581
25%	0.314134	0.1072305	**Sum of Wgt.**	581
50%	0.4727937		**Mean**	0.488017
		Largest	**Std. Dev.**	0.2134954
75%	0.6598525	0.9279971		
90%	0.7927378	0.9293918	**Variance**	0.0455803
95%	0.8451719	0.9383149	**Skewness**	0.148247
99%	0.9258309	0.9764684	**Kurtosis**	2.021919

Covariate imbalance testing

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.147	119.92	0	19.6	17.7	95.0*	1.3	42
Matched	0.011	7.7	1	3.2	2.6	24.2	1.41	33

* if B>25%, R outside [0.5; 2]

Propensity Score Density



Source: Authors

Alternative Regression Models

Alternative Regression Models (Poisson regressions)			
Variable/ Regression	**Food Security**		**Income**
Dependent Variable	**MFHP**	**HDDS**	**Number of income sources**
Bridges	0.02*	-0.02	0.34***
Climate Shock	-0.04***	-0.06***	-0.05
Annual Mean Temperature	0	0.01	0.05***
PRODECOOP	0.04***	0.03	0.03
UCA SJRC	0.02	-0.13***	-0.03
QUILALI	0.01	0.01	-0.06
SAN JUAN DE RIO COCO	0.01	0.03	0.01
HH head age	-0.00***	-0.00*	0
HH head years of education	0	0.01**	0
HH size	-0.01***	0	0.01
Total Area Has (used)	0	0	-0.01*
% Coffee Area	-0.05*	0	-0.22***
Total incomes (US$)	0	0.00*	0.00***
Pigs (units)	0	0.01	-0.01
Poultry (units)	0	0.00***	0
Cattle (units)	0.00***	0	0
Quintile 2 of Wealth Index	-0.02	0.02	-0.03
Quintile 3 of Wealth Index	0.03	0.05	0.08*
Quintile 4 of Wealth Index	0.03	0.08**	0.09**
Quintile 5 of Wealth Index	0.04	0.14***	0.14***
Distance to markets (minutes)	0.00**	-0.00***	0
Credit	0.01	0.01	0.01
Wet coffee processing	0.01	0.04*	0
Silos	0	-0.01	0
Filter box (zaranda)	-0.01	0.01	0.09**
Chain pump	-0.01	0	0
Warehouse supplies	0.01	0.02	-0.03
Plastic barrel	0.01	-0.02	-0.03
Metallic barrel	0.02*	0	-0.01
Electricity	0.01	-0.06***	0.06*
Average nr of rooms	0.01**	0.01	-0.03**
Mud walls	0.01	-0.03	-0.02

Brick walls	-0.01	0	-0.01
constant	2.21***	1.87***	-0.12
Number	588	588	588
Chi Sqrt	256.49	293.58	327.74
Log-Likel	-1262.16	-1197.18	-893.56
LRI	0.01	0.03	0.04
AIC	2592.32	2462.36	1855.12

*** $p<0.01$, ** $p<0.05$, * $p<0.1$