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HAITI

AGRICULTURAL AND AGROFORESTRY TECHNOLOGICAL INNOVATION PROGRAM

(HA-L1107)

MONITORING AND EVALUATION PLAN

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Contents

Abbreviations

Ha	Hectare
HTG	Haitian Currency *(Gourdes)*
IE	Impact Evaluation
MARNDR	Haitian Ministry of Agriculture *(Ministère de l'Agriculture, des Ressources Naturelles et du Développement Rural)*
M&E	Monitoring and Evaluation
PITAG	Agricultural and Agroforestry Technological Innovation Program (*Programa de Innovación Tecnológica Agrícola y Agroforestal*)
PMR	Progress Monitoring Report
PTTA	Technology Transfer Program for Small Farmers

I. INTRODUCTION

1.1 The general objective of the Program is to increase agricultural income and food security for smallholder farmers in selected areas of Haiti. The specific objective is to increase agricultural productivity and improve the use of natural capital through the adoption of sustainable technologies. To reach these objectives, the program is structured around two components: (1) Applied Research and Training; and (2) Promotion of Sustainable Agricultural Technologies.

1.2 The Monitoring and Evaluation System will rely on three components:

i. Biannual monitoring reports prepared by a monitoring officer affiliated to the Executing Agency of the Agricultural and Agroforestry Technological Innovation Program (see Part II).

ii. Mid-term and final independent evaluations (the latter will include an ex-post economic analysis of the project using the same methodology as the ex-ante economic analysis but with actual project data, and both will include an evaluation of the technology transfer schemes included in the program) focusing on the project's effectiveness, efficiency, sustainability, relevance and coherence.

iii. An external impact evaluation based on experimental and quasi-experimental methods (see Part III).

1.3 The Executing Agency of the Agricultural and Agroforestry Technological Innovation Program (PITAG) will be responsible for the operational monitoring of the project at all levels (Components I and II). Consulting firms will be contracted by the executing agency to carry out mid-term and final independent evaluations as well as for the implementation of the impact evaluation.

II. MONITORING

A. Output Indicators

2.1 Based on the complete results matrix of the project, the monitoring will consider the following output indicators:

Table 1
Output Indicators

Indicator	Frequency of Measurement	Source of Verification
Component I: Applied research and training		
1.1. Applied agricultural research projects implemented for the development/adaptation or improvement of new agricultural technologies **MS. 1.1.1.** Applied agricultural research projects implemented for the development/adaptation or improvement of agricultural technologies that specifically target female farmers	Biannual	Project progress reports and IDB inspection visits
MS. 1.1.2. Applied agricultural research projects implemented for the development/adaptation or improvement of agricultural technologies that specifically target climate change adaptation or mitigation		
1.2. Scholarships to support the implementation of new innovation projects delivered to research fellows		
1.3. Directorate of Innovation strengthened		
MS. 1.3.1 Innovation Information system implemented		
Component II: Climate Risk Reduction		
2.1. Number of beneficiary farmers who received technological packages	Biannual	Project progress reports and IDB inspection visits
MS. 2.1.1. Number of female farmers who received technological packages		
MS. 2.1.2. Number of beneficiary farmers who received technological packages for climate change adaptation and mitigation**.**		
2.2. Number of beneficiary farmers who received technical assistance		

B. Data Collection and Instruments

2.2 The Program's full-time monitoring officer will be responsible for the monitoring of all the output indicators described in **Table 1**. Monitoring data will be compiled mainly from:

- On-site visual inspections;
- The Program's Information System.

C. Reporting

2.3 The executing agency will prepare and transmit to the Bank a biannual activity report that will include the results of the monitoring of all the output indicators listed above. The preparation by the executing agency and the Bank's approval of these reports is a contractual condition of the grant. At the end of the project (year 5), the executing agency will prepare a final report.

2.4 These reports will provide all the required information for the Progress Monitoring Report (PMR) system of the Bank, which will be updated on a biannual basis by the specialist in charge.

2.5 The entity contracted to carry out the impact evaluation will submit a biannual report on data collection activities and data analysis. This report will be transmitted to the Bank for approval. This constitutes another contractual condition of the grant.

2.6 Biannual monitoring reports are due one month after the end of each semester (i.e. on January 31st and July 31st).

D. Independent Evaluations

2.7 The executing agency will submit to the Bank a mid-term independent evaluation report within 90 days after the date on which 50% of the grand proceeds have been committed. The objective of this evaluation will be to determine whether execution is satisfactory and whether the project's strategy is generating the desired impact, or whether adjustments are needed. For each Component, it will highlight the key issues that are faced and which require responses from the executing agency. It will also provide a set of preliminary insights about the project's design, implementation, and management.

2.8 A final independent evaluation will be carried out a few months before the end of the project at year 5 to determine whether it has reached its objectives. The evaluation team will report the results of the project's impact evaluation as well as identify the lessons learned through the project and in particular its key successes and failures. The team will also assess the sustainability of the project's results and propose a set of recommendations to the various project's stakeholders in order to reinforce it.

2.9 **Table 2** provides details on the entities responsible for the supervision of the independent evaluations as well as budgetary allocations for each activity and source of funding.

Table 2
Independent Evaluations Work Plan

Activity	Year 1				Year 2				Year 3				Year 4				Year 5				Responsible	Cost (currency)	Source of Funding
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4			
Mid-term evaluation																					MARNDR	US$ 50,000	Project Budget (M&E category)
Final evaluation																					MARNDR	US$ 75,000	Project Budget (M&E category)

E. Monitoring Coordination, Work Plan and Budget

2.10 **Table 3** provides details on the responsible entities for the implementation of the monitoring plan, monitoring activities, budgetary allocations for each activities and sources of funding.

Table 3
Monitoring Work Plan

Activity	Year 1				Year 2				Year 3				Year 4				Year 5				Responsible	Cost (currency)	Source of Funding
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4			
Inspection visits																					IDB	US$ 10,000	IDB Transactional Budget
Day-to-day project monitoring																					Monitoring officer	US$ 150,000	Project Budget

III. EVALUATION

A. Logic of the intervention

This section describes *the problem* that aims to be tackled with the PITAG, the main factors that *cause* this problem and *the intervention* that is proposed to solve the identified problems.

The problem: Low productivity, stagnated income and high food insecurity

The agricultural sector is strategic for the Haitian economy. Agriculture plays a major role by contributing 25% of GDP and 85% of employment in rural areas[1]. The gap between local production and the demands of an increasing population has progressively widened over the years. Today, the country only satisfies 45% of its food needs and is dependent on imports of food products such as wheat, rice, sugar, oil and poultry. The deficit is essentially covered by massive imports of food products.

Food insecurity is widespread in Haiti. The country is ranked 115th out of 118 countries in the 2016 Global Hunger Index (GHI), with a GHI score of 36.9, which places it in the alarming category. Results of a recent World Food Program (WFP) analysis (2015) indicate that approximately 47% of the households are moderately or severely food insecure. In addition, households with children of less than five years of age are much more exposed to frequent food shortages[2]. As a consequence, one fifth of children less than five years old are chronically malnourished (DHS, 2012)[3].

Haitian agriculture presents very low levels of productivity compared with other countries in the region (as shown in Table 1, for the main crops grown in Haiti). Labor and land productivity have been declining in the last two decades[4]. Also, total factor productivity declined at an annual average of -0.5% in the period 2001-2012 (compared with a 1.7% average growth for the Latin America and Caribbean region)[5].

Table 1: Yields for main Haitian crops compared to regional yields[6]

Product	Haiti's yields as % average yields in Central America and the Caribbean
Cocoa	99%
Mango	91%
Plantains	60%
Sorghum	39%

[1] UNDP, 2015.
[2] World Bank and ONPES, 2014.
[3] Haiti Demographic and Health Surveys.
[4] Cirad, 2015.
[5] Nin-Pratt, A. et al., 2015.
[6] Countries considered for this comparison are Central American and Caribbean countries included in the FAOSTAT database, years 2010-2014.

Product	Haiti's yields as % average yields in Central America and the Caribbean
Avocado	47%
Banana	25%
Cassava	59%
Maize	39%

The low agricultural productivity in Haiti translates into low income and food insecurity. Per capita income in the Haitian agricultural sector has stagnated in recent years. Annual agricultural GDP per capita is currently estimated at US$ 400 per year.

Causes of the problem

(i) Among the many factors that contribute to low productivity in the country is the low access to technologies which is explained by the financial constraints faced by farmers. In particular, access to credit is highly restricted, particularly in rural areas, where financial markets are thin or non-existent. In addition, Haitian legislation does not allow farmers to use land as collateral for credit purposes. Data collected for the evaluation of the agroforestry technology provided by PTTA shows that only **28% of the farmers have a bank account and 19% have received a credit** for agricultural purposes. Lack of information about existing technologies, farming techniques, access to markets, natural risks and climate change is also a contributing factor. The majority of producers in Haiti are therefore still using basic techniques predominantly for subsistence agriculture and lack access to certified high quality seeds, appropriate soil conservation techniques, inputs for production (i.e. pesticides and fertilizers[7]) as well as basic tools and equipment. The General Agricultural Census (RGA) shows that only 7% of the farmers used mechanical equipment. Also, the baseline data collected for PTTA shows that only 9% of the farmers had used improved seeds and only 22% have knowledge of certified seeds.

(ii) Lack of financial and human resources to develop agricultural innovation. Agricultural research and extension has been virtually non-existent in Haiti for nearly three decades[8]. Aggregate numbers show that over the last three decades technical efficiency in the Haitian agricultural sector has fallen drastically, at a -1.8% average yearly rate (Nin-Pratt, A. et al. 2015). This is a reflection of an outdated institutional research framework, and the lack of technology transfer and extension systems. The lack of local expertise in applied and adaptive agricultural research as well as technology transfer is in turn

[7] In a study conducted by USAID in the North of Haiti in 2017, it is estimated that 28% of farmers use pesticide. Fertilizers is used by 4% of cacao producers, 13% of banana producers and 95% of rice producers.

[8] Cirad, 2015.

partially explained by the lack of training and educational opportunities in these areas. The 2009 RGA reports that 43% of the farmers identified weak agricultural research and extension services as a constraint for the development of the sector. Moreover, only 2.6% of farmers mentioned receiving some type of technical assistance.

(iii) Climate risks. Haiti is one of the countries with the highest Climate Risk Index (CRI Germanwatch, 2016) and natural disaster risk index in the world (WB, 2005; UNDP, 2004), including climate hazards (Kreft et al., 2015). The climatic risks faced by farmers and their ability to cope with them also limit the long-term growth of the productivity of the agricultural sector in Haiti. For instance, hurricane Matthew caused severe economic damages and losses that amounted to US$ 1.9 billion. The damages and losses in perennial crops (coffee, cocoa, breadfruit, coconut, avocado, citrus and other fruit) and timber, which are extremely important for food security and rural income, were particularly high and represented US$ 433 million, further decreasing capital assets and sources of income for Haitian farmers. For the future, climate models predict temperatures to increase up to 0.8°C for the 2020s; and precipitation scenarios a drying trend in the mid-2020s with 3 to 4 % less rainfall in the annual mean (IDB, 2016), translating into losses of 25% in average in key cultures such as banana, manioc and beans. (UNDP, 2015)

The intervention

The PITAG aims to tackle the aforementioned problems by financing applied research agricultural projects that increase the supply of innovative technologies catered towards Haitian agriculture. Also, the project aims to promote the adoption of sustainable agricultural technologies by financing part of the cost of a technology chosen by the farmers.

Component I: Applied research. This component will finance the following activities: First, the development and implementation of applied and adaptive agricultural research projects developed and implemented by national and/or international institutions. These research projects will create, improve and/or adapt sustainable agricultural technologies that will enhance the supply of technological options available to farmers. Six main projects were identified through a priorization exercise that considered economic, social, and environmental aspects as well as the technology gap with other countries in the region (rice, banana, roots, vegetables, legumes, and agro-forestry systems). All research projects will include climate considerations and foster adaptation and mitigation measures. Seven additional smaller projects will be demand-based. Second, the strengthening of the higher education curriculum through activities conducted within the research projects, in order to improve applied and adaptative research and technology transfer capabilities in Haiti. Third, the institutional strengthening of the MARNDR *Innovation Directorate* (ID), through: (a) technical and scientific support; (b) materials and equipment; and (c) strengthening of the technical and scientific profile of its professionals. The Component will be executed by the Innovation Directorate of the MARNDR. The selection of the various proposals will be conducted by a panel composed by Ministry staff and external experts. The results of Component 1 will progressively provide input for the technology menu promoted by Component 2, including climate considerations.

<u>Component 2</u>: Promotion of sustainable agricultural technologies. This component will finance the adoption of profitable, climate smart, and sustainable agricultural technologies that will improve farm profitability, generate positive environmental externalities, and facilitate the mitigation and adaptation to climate change. The component will be implemented through the agricultural incentives program conducted by the MARNDR. The technology menu has been selected through a priorization exercise conducted with the MARNDR and will include: pre-harvest, harvest and post-harvest technologies (small irrigation equipment, plowing equipment, etc.) as well as sustainable soil recuperation and conservation practices (i.e. agro-forestry systems, sustainable soil management techniques)[9]. The component will cover 90% of the costs of the technologies through a matching grant, and farmers will cover, in cash, the remaining 10%. In the areas affected by Hurrican Matthew, South and Grand Anse Departments, the component will finance the total cost of the technologies. The component will also finance: an information system for program implementation, technical assistance for farmers, and technical assistance for technology providers. The technical assistance for farmers will be provided by the providers (specific technical assistance on the use of the technologies) and by technical operators (strategic technical assistance on farm practices). These same operators will also provide technical assistance to the providers.

<u>Justification for the use of Public Resources to Finance Technology Adoption</u>

From an economic perspective, several reasons justify public investment in agricultural research and training, as well as technology transfer services to farmers. In fact, the literature recognizes the existence of several market failures that hinder the process of agricultural technology adoption in developing countries, including: (i) lack of access to information and/or asymmetric information; (ii) input and output market inefficiencies (Feder, Just and Zilberman, 1985; Jack, 2013); (iii) liquidity constraints and insufficient access to credit; and (iv) risk aversion.

The lack of information limits technology adoption not only because agricultural producers lack knowledge on the effective use of these technologies, but also because they lack information regarding location of private providers or costs of production. For instance, in the case of Nepal, Joshi and Pandey (2005) show that farmers' perceptions regarding different rice varieties influence adoption decisions. Therefore, the authors conclude that it is important to disseminate information broadly using different methods to form accurate perceptions of the technologies to be promoted among farmers. Similarly, Conley and Udry (2004) demonstrate the importance of learning and information effects on the technological adoption in Ghana. Specifically, the authors show that pineapple producers changed their input use patterns only when they gained access to information regarding production yields from neighboring farmers. Finally, Bentley et. al (2011) measured the effect of farmers´ field schools where free information regarding plant health and agricultural practices is provided to farmers in Bolivia. The authors found that

[9] The initial list of technologies includes: motor-pompes, animal traction, cane mills, threshers, stocking equipments, different types of agroforestry packages, different types of forestry packages, forages.

adoption rates are higher (about 82%) for producers who received the information, in comparison with the control group.

As for the presence of thin markets for technology providers in rural regions, this is mainly caused by the small population density spread in remote and large areas without accessible roads and high transaction costs (IFAD, 2003). Therefore, it is not profitable for technology providers to be located in areas under these conditions without certainty about potential demand. On the other hand, it is difficult for farmers to reach technology providers as these are primarily located in urban or suburban areas.

The presence of liquidity constraints and credit restrictions is one of the principal factors that limit smallholder farmers' technology adoption, as mentioned (cfr. paragraph 1.6).

Finally, the fourth obstacle that limits technology adoption is risk aversion. This factor limits technology adoption because producers prefer to have certainty regarding the future yields that will be obtained with new technologies before incurring the initial cost. Thus, producers tend to postpone technology investments until they can confirm the benefits associated with the adoption of such technologies through experience from other farmers (Feder, 1980). Several studies provide evidence on the negative impact of risk aversion on technology adoption such as Abadi Ghadim, Pannell y Burton (2005) and Besley and Case (1994), which in the case of Haiti could be further accentuated by climate uncertainty.

The Agricultural and Agroforestry Technological Innovation Program (PITAG) aims to improve technology adoption by reducing the aforementioned market failures. Specifically, the provision of a matching grant that partially covers the cost of an agricultural technology aims to ease liquidity and credit constraints faced by smallholder farmers. Secondly, the provision of technical assistance to farmers aims to reduce the barriers related to risk aversion. Lastly, the implementation of technology fairs aims to reduce the lack of information and eliminate problems related to shortage of supply and thin markets by bringing together demand (small farmers) and supply (technology private providers).

The Theory of Change

It is expected that by increasing the adoption of agricultural technologies and agroforestry systems the project will increase agricultural productivity and improve the use of natural capital, particularly reduce soil degradation. Higher productivity will translate into higher agricultural income from crop sales as well as production for home consumption. Higher income will facilitate access to food consumption which will improve food security. On the other hand, higher production will enhance food availability which will also improve food security. Diagram 1 presents the theory of change and Table 2 presents the indicators that will be used to measure results and impacts.

Theory of Change

OUTPUTS

1. Development of research projects (new technologies)
2. Provision of technical assistance
3. Delivery of technical packages (technologies)

INTERMEDIARY RESULTS

1. Increase adoption of agricultural technologies
2. Improve agricultural innovation services

RESULTS

1. Increase agricultural productivity through the adoption of agricultural technologies
2. Improve use of natural capital thorugh the adoption of agroforestry packages that improve soil quality

IMPACTS

1. Increase agricultural income
2. Improve food security

B. Impact and Results Indicators

Impact	Indicator	Frequency of Measurement	Validation source
Impact 1. Improve Food Security	**Indicator 1.1:** Percentage of male-headed households who are severely food insecure using the Food Security Scale (ELCSA) **Indicator 1.2:** Percentage of female-headed households who are severely food insecure using the Food Security Scale (ELCSA) **Indicator 1.3:** Beneficiaries of IDBG projects that contribute to at least one key dimension of food security	2018 and 2022	Agricultural Household Surveys for baseline and follow-up. Disaggregated by sex of the head of the household.
Impact 2. Increase Agricultural Income	**Indicator 2.1**: Annual agricultural household income **Indicator 2.2:** Annual agricultural profits (agricultural revenues minus cost of variable inputs and transportation)	2018 and 2022	Agricultural Household Surveys for baseline and follow-up. Disaggregated by sex of the head of the household
Impact 3. Increase Agricultural Productivity	**Indicator 3.1: Annual value of agricultural production**	2018 and 2022	Agricultural Household Surveys for baseline and follow-up. Disaggregated by sex of the head of the household

Results	Indicator	Frequency of Measurement	Validation source
Result 1: Improve use of Natural Capital	**Indicator 1.1**: Beneficiaries of improved management and sustainable use of natural capital. **Indicator 1.2:** Beneficiaries who adopted soil protection and restoration technologies **Indicator 1.3:** Additional hectares of land applying agroforestry technologies	2018 and 2022	Records of beneficiaries from the Ministry. Agricultural Household Surveys for baseline and follow-up.
Result 2: Improve Agricultural Innovation Services	**Indicator 2.1:** Research and development expenditure as percentage of Agricultural GDP **Indicator 2.2:** New technologies developed or adapted by new applied research projects. **Indicator 2.3:** Male farmers who adopt the technologies developed by new applied research projects (Component I). **Indicator 2.4:** Female farmers who adopt the technologies developed by new applied research projects (Component I).	2018 and 2022	Ministry's executed budget. Records from the ministry of Agriculture.
Result 3: Increase Adoption of Agricultural Technologies	**Indicator 3.1:** Percentage of beneficiary producers who adopt agricultural technologies. **Indicator 3.2:** Percentage of beneficiary women who adopt agricultural technologies **Indicator 3.3:** Farmers who adopt agricultural technologies **Indicator 3.4**: Women beneficiaries of economic empowerment initiatives	2018 and 2022	Records of beneficiaries from the Ministry. Agricultural Household Surveys for baseline and follow-up

C. Empirical Evidence

Agricultural activity is the main source of income for Haiti, it represents 22% of the GDP and 57% of the economic active population is dedicated to it. However, agriculture is greatly fragmented in the country, it is mostly considered a family business and almost 33% is for self-consumption purposes (FAO, 2013), but agricultural production is still not enough to feed all the population and they have to import almost 50 percent of the food they need (USAID, 2016).

The total surface of the country is 2775 miles of hectares, from which 1840 are agricultural lands, including annual crops, permanent crops, meadows and pastures (FAO, 2013). However, centuries of agricultural exploitation, an increasing demand for charcoal and fuel wood have stressed the environment and have led to soil erosion and deforestation to be endemic problems in Haiti (McClintock, 2003). The great deforestation of the country began during the colonial period and was intensified in 1730 with coffee introduction, then other agricultural practices as monoculture and clean-cultivation caused rapid erosion and exhausted soil nutrients (Paskett and Philoctete, 1990). Most hillsides are eroded and a third of the land is severely degraded (White and Jickling, 1995), also gully erosion is chronic, what compromises soil fertility and infrastructure (Wahab et al., 1986). In addition to this, the lack of capital and land tenure in Haiti continues to constrain sustainable resource management.

1. Agroforestry

To begin with, according to USAID definition, agroforestry is "the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic and social benefit". It is to be remarked that the agroforestry practices have numerous benefits in different aspects, as mitigation of environmental damage, adaptation to climate change and increase of agricultural productivity.

One of the primary benefits of agroforestry practices is related to soil conservation (Young, 1989); the main effects on the soil are amelioration of erosion; maintenance or increase of organic matter and diversity; nitrogen fixation; enhancement of physical properties like soil structure, porosity, and moisture retention; and enhanced efficiency of nutrient use (Sanchez, 1987). Besides the environment benefits, agroforestry can actually improve agricultural productivity and therefore increase rural income. Pattanayak and Mercer (1996) analyze an agroforestry program implemented in Phillipines and find that agroforestry-related soil conservation benefits the farmer, increasing the annual gaining in 114 pesos. They propose that, although it itself is not sufficient incentive to invest in agroforestry; there are long run soil conservation benefits that should be taken into account.

In the case of Latin-America, the Environmental Program of El Salvador (PAES) is an example of how agroforestry incentives can produce positive results. This program had the objective of increasing farm-household income through improved soil productivity, adoption of conservation technologies and product diversification. Different studies of the PAES program show that the program is indeed associated with increased adoption of conservation practices and that the implementation of these practices, crop diversification and human capital formation have a positive and significant effect on household income (Cocchi, 2004; Cocchi and Bravo-Ureta, 2007; Bravo-Ureta, 2006).

In the same context, Bravo-Ureta et al. (2010) analyze the impact of MARENA Program in Honduras, which main target was to promote sustainable rural development by improving natural resource management and increasing productivity growth. They find positive results of MARENA Program on the total value of agricultural production (TVAP). Nonetheless these positive findings, some farmers remain reluctant to adopt new technologies or conservation practices. There are key factors related to the adoption of soil conservation technologies or new agricultural practices. Bravo-Ureta et al. (2006) find that the adoption of conservation practices and structures is directly related to schooling, crop diversification, technical assistance, participation in social organizations, among other factors. In the same way, Cocchi and Bravo-Ureta (2007) show that crop diversification and soil conservation practices are strongly and positively associated with the involvement of farmers with PAES and their participation in social organizations.

An impact evaluation that used a propensity score matching to assess the impact of the agroforestry component of the PTTA, shows that program participation had positive impact on the use of labor, the number of plots planted and increased expenditures in permanent plantules. Also, program participation increased expected profits, income and value of production.

2. **Research and Technology Transfer**

Research and technology transfer have been shown to be among the key determining factors of improvements in agricultural productivity over the past 50 years (Pardey et al., 2012). FAO (2012) reports that research and technology transfers are priorities in order to meet the growing demand for food because of their high returns. Specific studies obtain rates of return ranging from 43% to 67% for investments in research and technology transfer (Alston et al, 2014; Jin and Huffman, 2015).

In the case of technology transfer, there is evidence in the literature that provides rigorous evidence on the impact of similar programs in Latin America and the Caribbean. Gonzalez et. al. (2009) evaluate the impact of an agricultural technology transfer program, "Technological Support in the Agricultural Sector", that aims to reduce the barriers that limit technology adoption among farmers in the Dominican Republic. The study presents evidence that the adoption of the promoted technologies increased productivity levels for beneficiary producers of rice and livestock. Cerdán-Infantes et al. (2008) analyze the impact of the Programa de Servicios Agricolas Provinciales (PROSAP) in Argentina. This program provides extension services to grape producers. The authors find that the program increased the adoption of high quality varieties of grape.

Finally, in regards to food security, Salazar et. al (2016) assess the impact of the CRIAR program in Bolivia that aims to improve access to agricultural technologies through a voucher-based subsidy scheme. The results show that beneficiary households are 20–30% more likely to be food secure than the control group and 22% less likely to be concerned about lack of food. This increase was driven both by food availability – the annual value of production per hectare increased by 92% and the value of production sold by 360% – and food access – the results show that participation in CRIAR increased net annual agricultural household income by 36% and per capita household income by 19%. Also, an ongoing study of the PATCA II, that provides voucher-based subsidies to farmers to improve agricultural technology adoption, shows that beneficiary farmers increased food security by 27% (Salazar et. al., 2016).

D. Evaluation Methodology

As with every impact evaluation, the principal challenge is to find an appropriate control group or a counterfactual comparable to program beneficiaries. For this program, we will apply a combination of techniques that include: (i) reflexive analysis for results obtained from component I; (ii) randomized control trial for technologies delivered with component II with excess demand; and (iii) a double difference estimation combined with a propensity score matching for technologies delivered with component II without excess demand.

Reflexive Methodology (Component I).

This methodology aims to measure in a simple manner, the results obtained from component I. Specifically, this methodology will merely focus on measuring the outcome variables associated with Result 3: "Improve Agricultural Innovation Services", using a before and after the program comparison in order to identify any improvements obtained by the innovation program of the Ministry of Agriculture. The outcomes that will be measured using a before and after comparison are the following:

1. Research and development expenditure as a percentage of GDP by the government.
2. New technologies developed or adapted by new applied research projects.
3. Male farmers who adopt the technologies developed by new applied research component.
4. Female farmers who adopt the technologies developed by new applied research component.

The idea behind the methodology is to measure the indicator at $t=0$ (before the program) and the same indicator at $t=1$ (after the program). This methodology does not aim to capture rigorous causality, however, it will be useful information for the Ministry and the Bank. Also, given that the main idea is to measure the Ministry's advancements on agricultural innovation, using a before and after methodology guarantees that we are directly capturing the improvements obtained by this institution in terms of new technologies developed.

Experimental Methodology (Component II, technologies with excess demand)

This methodology aims to measure direct causality of program implementation by randomly assigning producers to beneficiary and control groups.

The randomization will be performed as follows:

1. The randomization will be conducted at the individual level.

2. The farmers who are interested to receive the technologies offered by component II of the program will register in a list where they will reveal their technology preferences.

3. The technologies with excess demand will be identified. This refers to technologies that surpass the limit of expected beneficiaries as established in the program's budget.

4. Farmers who selected technologies with excess demand will be randomly assigned to beneficiary and control groups.

5. Baseline data will be collected on beneficiaries and control groups prior to program implementation. This dataset will allow us to corroborate comparability between both groups.

6. Follow-up surveys will be collected on beneficiaries and control groups to identify program's impact.

A randomized control trial represents the golden standard for any impact evaluation because it guarantees that treatment and control groups are, on average, statistically the same across observable and unobservable pretreatment characteristics. Formally, under random treatment assignment, the expected outcome of the treatment group, $E(Y_{i1}|\, T_i = 1)$, is equal to the expected outcome of the control group had not received the treatment,$E(Y_{i1}|\, T_i = 0)$, and vice-versa, $E(Y_{i0}|\, T_i = 0) = E(Y_{i0}|\, T_i = 1)$. Hence, any observed differences in the outcomes of interest between the treatment and the control groups are attributed to the intervention.

Under random treatment assignment, an unbiased estimate of the average treatment effect can be calculated using Ordinary Least Squares (OLS) model as follows:

$$Y_i = \alpha + \beta T_i + \varepsilon_i \qquad (1)$$

Where Y is the outcome of interest, T represents treatment, and ε is an error term. In this case, the coefficient β represents the actual unbiased estimate of treatment.

The experimental methodology will serve to guarantee the comparability between treated and control groups as well as to assure transparency and equal opportunity of participation. The identification strategy will use an instrumental variable approach to measure the program's impact. Specifically, it is expected that some producers will not participate despite being selected for program participation. This can occur when farmers don't have the financial means to pay the remaining cost of the technology, when there are inappropriate agro-ecological conditions to adopt the chosen technology, among other factors. This problem is better known in the literature as non-compliance. Because the program cannot oblige farmers to adopt the technology, this problem is likely to take place in the evaluation. For this purpose, an instrumental variable approach will be conducted. However, this methodology will allow us to identify the local average treatment effect (LATE), which implies that we will be measuring the impact for those farmers who adopted the technology.

The instrumental variable technique will allow us to solve the *noncompliance* problem through the utilization of an instrument Z. This instrument must be related with the participation in PITAG but must be exogenous to the outcome of interest Y (i.e. technology adoption). Specifically, the instrument will have a value of 0 if the farmer was assigned to control group and 1 if the farmer was assigned to beneficiary group.

The main objective in this impact evaluation is to identify: (i) whether program participation enhances technological adoption and; (ii) if technological adoption increases productivity, income and food security. For this purpose, a two stage least squares must be estimated where the first stage calculates the impact of treatment on *Adoption* and the second stage calculates the impact of *Adoption* on the outcomes of interest *Y*. Formally, following the paper published by Salazar et. al (2016), this is the system of equations to be estimated:

$$PITAG_i = \alpha + \beta Z_i + \gamma X_i + \varepsilon_i \qquad (2)$$

$$Y_i = \propto + \pi \widehat{PITAG} + \rho X_i + \tau_i \qquad (3)$$

Where Z is the dummy for the randomization (instrument), *PITAG* is a dummy variable that takes the value of 1 if the household obtained the technology; Y_i is any of the outcomes of interest for the household *i*. These outcomes include the following: (i) $Adoption_i$ is a dummy variable that takes the value of 1 if the household *i* adopts the technology provided by the PITAG and 0 otherwise (also producers who adopted soil protection and restoration technologies as well as the amount of land where the technologies are applied)[10]; (ii) household value of agricultural production per year[11]; (iii) food security (using the ELCSA index of food security, see Annex 1 of this document)[12]; (iv) annual agricultural household income (this indicator will be measured separately to female and male head of households); and (vi) annual agricultural household profits (measured as agricultural income minus costs of variable inputs and transportation). Also, X_i is a matrix of control variables for household *i* including (socio-

[10] Includes the indicators 2.3, 2.4, 3.1, 3.2 in the results section of the Results Matrix.

[11] Indicator 1.1 in the results section of the Results Matrix

[12] Includes the indicators 1.1 and 1.2. of the impact section of the Results Matrix.

demographic characteristics, economic characteristics of the household, dummy variables at the regional level, and other pre-treatment characteristics); and ε_i is an individual error term.

It is considered that a simple randomization is sufficient to capture the overall program's impact. In other words, the objective of this evaluation is to identify the effect of the intervention as a whole, we are not aiming to identify specific heterogenous impacts at the technology or regional levels (however, we will control for regional dummies in the estimation).[13]

Another reason why a simple randomization is seemed sufficient to evaluate the program's impact is because strong spillover effects are not expected to take place, which could invalidate the methodology when present. Specifically, the main reason why spillover effects are not expected to take place to a considerable extent is due to the presence of liquidity constraints. Farmers to be benefited from this program face strong financial constraints which reduce their possibility to access the technologies by any other means than program participation. Evidence from a similar program in Dominican Republic (PATCA), corroborates this hypothesis (Aramburu, Maffioli, Salazar, 2017).

Propensity Score Matching and Difference in Difference (Component II, technologies without excess demand).

This methodology aims to measure the effect of the program for those technologies that might not have an excess demand. In this case, it is not possible to randomly assign producers to treatment. Therefore, we will identify non-treated communes located near the treated ones, in order to find producers that can be used as a counterfactual of the beneficiaries that access this kind of technologies.

The potential control communes are the following: (i) in the North: La Victoire, Pignon, Quartier Morin; (ii) in the North East: Carice, Ferrier; (iii) in the South: Saint Louis du Sud, Tiburon, and (iv) in Grande Anse: Corail, Moron.

We will use a Propensity Score Matching (PSM) to select a sample of control producers in these communes that are comparable to the beneficiary producers. In order to identify a proper

[13] Also, measuring heterogenous impacts at the technology level will imply using an extremely large sample size which will not be possible with the financial constraints of this evaluation.

counterfactual, the first step is to estimate the propensity score for the potential control producers and the beneficiary producers.

The propensity score is the probability of participating in the program, given certain characteristics. In the participation model, the dependent variable will be the inclusion in the program and the independent variables included in the vector X are composed of variables that can determine the participation in the program but are not affected by program participation, such as socio-economic characteristics, household characteristics, wealth, agricultural area owned, among others.

The proposed participation model to predict the probability of the producer to participate in the program is presented in the following equation:

$$\Pr(PITAG = 1|X) = \alpha + \beta \sum C_i + \delta \sum H_i + \rho \sum W_i + \varphi \sum L_i + \varepsilon_i$$

Where $\Pr(PITAG = 1|X)$ is the probability that the producer i participates in the PITAG Program; C_i is a vector of socio-demographic characteristics of the household, including number of household members, proportion of women and dependency ratio; H_i is a vector of head of household characteristics, including age, gender, marital status, literacy and education level; W_i is a vector of economic characteristics of the household, including non-agricultural income, reception of cash transfers, ownership of bank account and access to credit; L_i is a vector that captures the size of the land, including total area owned by the household and area effectively planted, and ε_i is the error term. After finding the propensity score for both, the treated and non-treated producers, we can "match" them using different matching algorithms and maintain the common support area, which is where the comparable observations are, ensuring the comparability between the treated and control group (Heckman et al., 1998).Using the observations in the common support area we can implement the difference in differences (DD) estimation, a quasi-experimental technique that allows us to identify the causal effect of the program by accounting for time-invariant observable and unobservable heterogeneity. The main assumption of this methodology, that in the absence of treatment the beneficiary and control groups will present similar trends, is guaranteed by the previous PSM implemented.

The following equation represents the basic difference in difference model to be estimated:

$$Y_i = \alpha_i + \beta_1 T + \beta_2 D_i + \beta_3 (T * D_i) + \delta_{ij} X_{ij} + \varepsilon_i$$

Where Y_i is the outcome variable of interest for household i; T is a dummy variable that equals to 0 if baseline and 1 if follow-up; D_i is a dummy variable that equals to 1 if producer i is treated by PITAG; X_{ij} is a vector of observable characteristics for household i, measured at baseline; α, β, δ are unknown parameters, and ε_i is the error term.

The outcome variables include household value of agricultural production per year, food security (using the ELCSA index of food security), annual agricultural household income and annual agricultural household profits. The parameter of interest is β_3 that represents the double-difference estimator or the causal effect of the program. The parameter β_1 captures the time trend of the outcome variable and the parameter β_2 represents the initial differences between treated and control groups.

E. Sample Calculation

The first step to determine the adequate sample size is to conduct power calculations. These indicate the minimum sample size needed to conduct an impact evaluation and to answer the question of interest (World Bank, 2007). For this calculation, there are some required elements:

1. Size of the impact on the indicators of interest
2. Standard deviation of the indicators of interest
3. Level of confidence (we use 95% confidence)
4. Statistical power level (we use power of 80%)

Using these four elements, the sample size can be estimated using the power formula:

$$N = \frac{4\sigma^2 \left(z_\alpha + z_\beta\right)^2}{D^2}$$

Where,

D = The expected impact on the variable of interest

σ = The standard deviation of the variable of interest

z_α = The critical value for the confidence interval for a bilateral or two-tailed test.

z_β = The critical value of a statistical power for a bilateral or two-tailed test.

In this case, the calculations for the sample size are based on the data collected for the evaluation of the Agroforestry component of the PTTA, which provides information from 290 households of small agricultural producers from the commune of Limbé, in the north side of Haiti. This data set is used to obtain the mean values and standard deviations of the variables of interest, as well as the minimum detectable effect.

The third and fourth elements are indicative of the extent to which the sample is able to limit errors in the impact calculation. The critical value associated with the 95% confidence level (z_α) is 1.96 and the value associated with 80% power (z_β) is 1.28.

The following table shows the sample size required to measure the impact of the program on different variables of interest (as value of production and agricultural income) when the impact that we are trying to identify is of 20%, 40% and 50%

Outcome Variables	Mean	Est. Dev.	D=20%	D=40%	D=50%
Value of production , USD	358.8	663.3	2855	**714**	456
Agricultural income, USD	172.8	439.5	5238	1310	**838**

Given the effects found in the impact evaluation of the agroforestry component of PTTA and the results matrix of PITAG, the sample size must be able to identify an impact of 40% on value of production and 58% on income (highlighted in blue). The most restrictive sample size corresponds to the 50% impact on income which will be used hereafter. For the purpose of the evaluation, this sample has to be representative for male and female headed households. Then, the sample size will be twice the estimated number which corresponds to 1,676 surveys in order to account for impacts on female and male headed households. Assuming a non-response of 15%, the sample size will be equal to 1,927 surveys. To facilitate calculations, we will consider a sample size of **2,000 surveys (1,000 beneficiaries and 1,000 controls).**

F. The Questionnaire

The questionnaire will be an agricultural household survey with detailed information regarding agricultural production, input use, land allocation, livestock production, household socio-economic characteristics, income sources, food security, among others. Table 3 presents the main sections of the questionnaire.

Table 3: Sections of the Questionnaire

SECTION
Section 1: HH information Section 1.1: Identification of HH members Section 1.2: Information on education, health and work
Section 2: Plots information Section 2.1: List of plots Section 2.2: Information about plots owned Section 2.3: Information about plots rented Section 2.4: Information about leased plots Section 2.5: Information about purchase and sale of land Section 2.6: Information about the use of agricultural technologies on plots
Section 3: Crop information Section 3.1: List of annual crops Section 3.2: Seeding of annual crops

Section 3.3: Use of agricultural inputs on annual crops Section 3.4: Labor used for annual crops Section 3.5: Annual crops production Section 3.6: Annual crops storage and commercialization Section 3.7: Production of perennial crops and fruits Section 3.8: Labor used for perennial crops Section 3.9: Perennial crops storage and commercialization Section 3.10: Crop losses (including losses from fruit fly)
Section 4: Livestock information Section 4.1: Livestock inventory Section 4.2: Livestock production
Section 5: Farmers organization membership
Section 6: Housing: Section 6.1: Status of housing occupancy Section 6.2: Physical characteristics of the house Section 6.3: Water and sanitation Section 6.4: Electricity
Section 7: Assets, Income and expenditures Section 7.1: HH assets Section 7.2: HH incomes Section 7.3: HH expenditures Section 7.4: Food expenditure and consumption
Section 8: Access to finance Section 8.1: Informal savings Section 8.2: Bank accounts Section 8.3: Credit
Section 9: Food security Section 9.1: Dietary diversity Section 9.2: HH hunger scale

G. Budget

The expected costs for the impact evaluation includes: (i) costs associated with the administration and supervision of the collection of household surveys collection; (ii) the data entry and cleaning; (iii) the analysis of baseline and follow-up surveys; and (iv) field-work coordinator. The costs are estimated based on the previous agricultural household surveys collected in Haiti which about US$120 per survey (including GPS coordinates).

Table 4 presents the timeline for the implementation and the estimated costs:

Table 4. Budget for Impact Evaluation

Activity	Year: 2018	2019	2020	2021	2022	Costs (US$): Unitary Costs	Units	Total Costs
Questionnaire Design								
Pilot of the questionnaire to 70 farmers								
Baseline (BL) collection						100	2000	200,000
Baseline supervisión and data entry						30,000	1	30,000
Baseline Analysis						25,000	1	25,000
Questionnaire Design								
Pilot of the questionnaire to 70 farmers								
Collection of follow-up surveys						100	2000	200,000
Supervision of survey collection and data entry						30,000	1	30,000
Impact Evaluation						35,000	1	35,000
Imprevistos								30,000
							Total	**$550,000**

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Annex 1: Construction of the FAO Food Security Index

In order to obtain a measure of food security for the households we used the food security index developed by the FAO and based on the Latin American and Caribbean Food Security Scale (ELCSA by the Spanish acronym). This index consists of a list of 15 questions that capture the degree of households' accessibility to food capturing objective (number of meals per day, variety of food) and subjective assessments (concern for food deprivation).

These 15 questions are divided into two sections: one with 8 questions relating to food insecurity experienced by adults; and a second section (questions 9 to 15) with the same questions relating to conditions affecting specifically children under 18 years of age in the household. The first 8 questions are the following:

During the last 3 months, because of a lack of money or other resources, was there a time when:

1. You were worried you would run out of food?
2. Your household ran out of food because?
3. You or any adult in the household were unable to eat healthy and nutritious food?
4. You or any adult in the household ate only a few kinds of foods?
5. You or any adult in the household had to skip a meal?
6. You or any adult in the household ate less than you thought you should?
7. You or any adult in the household were hungry but did not eat?
8. You or any adult in the household went without eating for a whole day?

According to this index, the levels of food insecurity raise as positive responses are given. The classification of households within each category of food (in)security is performed taking into account the cutoffs shown in the following table:

Type of Household	**Food (in)Security Status - Number of Positive Responses**			
	Security	**Mild Insecurity**	**Moderate Insecurity**	**Severe Insecurity**
Household with adults only (they answer the first 8 questions only)	0	1 to 3	4 to 6	7 to 8
Household with adults and children under 18 years of age (they answer 15 questions)	0	1 to 5	6 to 10	11 to 15

In general, regardless the level of food insecurity, a household is considered food insecure if it shows mild, moderate or severe food insecurity.

The cutoff points were determined given the conceptual basis of ELCSA along with the use of statistical models applied to check for the external validity of the scale (FAO, 2012).