Food and Agriculture Organization of the United Nations

FUNDING PROPOSAL TO THE GREEN CLIMATE FUND

– RELIVE –

REsilient LIVElihoods of vulnerable smallholder farmers in the Mayan landscapes and the Dry Corridor of Guatemala

ANNEX. Carbon Estimates

March 2020

Republic of Guatemala

Contents

Carbon Estimations

1. Background

1. The objective of the RELIVE project is to restore critical ecosystem services in productive landscapes, increase climate-resilient and sustainable development of small vulnerable farmers in the Maya landscapes of Petén, the Verapaces and the Dry Corridor of Guatemala. This will be accomplished through the promotion of innovative solutions accompany by financial incentives to support protection. These actions are aimed to increase livelihood resilience and reduce risks to climate change while providing food security to vulnerable rural households. The project will benefit directly and indirectly more than 18,600 families.

2. Multiple scenarios show that the country will be seriously affected by the impacts of climate change, being the poor the most affected, which is why the project focuses especially on this historically vulnerable population. In the project´s prioritized municipalities, most of the population (66 to 76%) live in rural areas. The production of farmers is mainly maize, beans, coffee, cacao and green vegetable. Therefore, the project plans to work on measures for the adaptation of maize and bean agricultural systems, together with family vegetable gardens to improve the resilience of family agriculture, ensuring sufficient production and diversification of foods in the families' diet. Additionally, specific measures will be promoted to adapt coffee and cacao agroforestry systems and make them more resilient to pests and diseases, so to improve the quantity and quality of the production, the processing modalities of both products, and the community organization as a way to increase farmers' possibilities of accessing markets and obtaining better prices for their products.

3. Although the project objective is to support national climate change adaptation in agricultural and forestry systems, the typology of interventions proposed have mitigation co-benefits. In this context, the quantification of GHG emission is an important step to highlight this benefit. It also offers an opportunity to identify how the project actions provide win-win situations in delivering both adaptation and mitigation objectives which are equally important considering the climate change context.

2. Methodology

4. The 2030 Agenda and Paris Agreement tied the knot between sustainable economic development and a climate-resilient, low greenhouse gas (GHG) emissions future. Moving forward, accounting for potential changes in GHG emissions will be a vital component of any agricultural investment, project, or policy proposal under consideration by any country, institution, or organization. To support the international community's efforts with quantifying changes in GHG emissions, the Food and Agriculture Organization of the United Nations (FAO) developed the EX-Ante Carbon-balance Tool (EX-ACT[1]). Based on the Intergovernmental Panel on Climate Change (IPCC) methodology, EX-ACT provides its users a

[1] http://www.fao.org/fileadmin/templates/ex_act/pdf/Technical_guidelines/EX-ACT_technicaldescription_EN_v7.pdf

consistent way of estimating and tracking the impact of agricultural, forestry, and other land-use (AFOLU) investments and policies on GHG emission levels. EX-ACT is a free, open-source, Excel-based model and is available in all UN languages. GHG accounting has become a common practice for many international financial institutions as part of their project preparation. EX-ACT is widely used to assess the impact of agricultural and forestry projects on GHG emission and carbon sequestration. Its use includes ex-ante assessments of GEF projects, forestry and agricultural investment projects at the World Bank, Development Banks among others. Like an economic-financial analysis, Ex-ACT allows the assessment of a project's net carbon-balance, defined as the net balance of CO2 equivalent GHG that were emitted or sequestered because of project implementation actions compared to a without project scenario. This incremental benefit is what truly reflects whether a particular action taken mitigates or generates emission and thus makes the "GHG" bankable per se.

Ex-Act is a calculator tool and like all other globally available carbon accounting tools, follows the guidelines, methodologies and calculations formulas issued by the World Reference body on Climate Change, the IPCC[2]. The tool is widely used by World Bank investment projects and has already been used in the preparation of GHG analysis for various green climate fund projects. This analysis is based on the use of the Ex-Act tool. The methodology and calculations used in Ex-Act are well documented and follow the Guidelines for National Greenhouse Gas Inventories generated by the IPCC (2006). The tool provides a set of default coefficients based on global observations. However, users have the oppournity to update coefficients if regional/national (tier 2) are available. The methodology is complemented with additional calculations and emissions coefficients associated with agricultural/forestry production systems, farm operations and inputs which are based on literature reviews acceptable to the scientific community[3]. Default emission coefficient for mitigation options in the agricultural sector are mostly from Smith et al. (2007)[4]. Other coefficients such as embodied GHG emissions for farm operations, inputs, and transportation and irrigation systems implementation are from Lal (2004)[5]. The specific methodologies/calculations used in each of the modules are summarized in Table 1, of this publication[6]. The specific technical guidelines describing the methodology and calculations employed by the tool are described in the following publication http://www.fao.org/tc/exact/user-guidelines/en/

5. The Ex-Act tool was designed specifically to support ex ante assessments of agricultura, cattle raising and forestry projects. It is a land-based accounting system which estimates carbons tocks changes as well as emission generated from AFOLU activities. It consists of seven topic modules that allow to analyze a range of activities including crop production, land rehabilitation, forest management, livestock and grassland production systems among others. The ex-ante evaluation assesses how the impacts of a planned intervention compares to the business as usual scenario. The calculator requires data for 3 specific points in time: initial situation, with project scenario, without project or BAU. In preparing this data a lot of work is required up front to determine the adequate modeling of activities/interventions in the tool. This takes into consideration technical specificities, conversations with national staff to determine current

[2] IPCC, 2006. Guidelines for National Greenhouse Gas Inventories, Hayama: IGES.

[3] Carbon Accounting Tools for Sustainable Land Management. Collaboration of FAO/World Bank/GEF http://documents.worldbank.org/curated/en/318251544164909341/Carbon-Accounting-Tools-for-Sustainable-Land-Management

[4] Smith, P. et al., 2007. Agriculture. In: B. Metz, et al. eds. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the. Cambridge and New York: IPCC, pp. 497-540.

[5] Lal, R., 2004. Carbon Emission from Farm Operations. Environment International, 30(7), pp. 981-990.

[6] http://www.fao.org/fileadmin/templates/ex_act/pdf/Technical_guidelines/EX-ACTUserManuaFinal_WB_FAO_IRD.pdf

and future projections, literature reviews to assess availability of tier 2 or 3 coefficients to improve the accuracy of the assessment in case they exist. Once all this information is gather then based on technical expertise a plan on how to best model the intervention in the tool along with the assumptions made is generated. This is a crucial step as this is what really determines the measurement of the impact. All these aspects are discussed below to ensure a clear and transparent understanding of the assessment done for this project.

3. Project Boundaries and Data sources.

6. **Geographical coverage.** Guatemala is located in Central America and borders on Mexico to the north and west, with the Pacific Ocean to the southwest, with Belize to the northeast, with Honduras to the southeast and with El Salvador to the southeast. It has an area of 108,889 square kilometers and is the most populous country in Central America with a population of 15.6 million (estimate for 2014). The country has bimodal seasonal rainfall, with a humid northern hemisphere summer and a dry northern hemisphere winter season.

The RELIEVE project has been divided into three components, each of them comprising two or three Products and multiple practices that can be resumed as below:

<u>Component 1</u>. Implementing climate resilient agricultural practices and enhancing farmers' livelihoods.

- Product 1.1. Climate and agro-weather information improved and tailored to the needs of vulnerable smallholder farmers to inform adaptation measures.
- Product 1.2. Adaptation measures adopted to foster the resilience of coffee, cocoa and basic grain production systems.
- Product 1.3. Promotion of the resilience of livelihoods through 3,300 farmers on coffee and cocoa, processing and marketing activities.

Practices:

1- Access to climate information and crop technologies.
2- Introduction and use of improved, drought-resistant and open pollination basic grain seeds.
   This practice consists of introducing and using improved, open pollination varieties tolerant to unfavorable climate factors (e.g. high temperatures, droughts, excess rainfall, pests and diseases exacerbated by climate changes).
3- Agrobiodiversity diversification and creation of a favorable microclimate in the parcel.
   This practice consists of the introduction and establishment of fruit, timber and service trees (including for firewood), plus some species of roots and tubers, all drought resistant, strategically spread through the production parcel, specifically basic grains and family vegetable gardens.
4- Improving the organic matter content and soil humidity retention capacity by managing stubble and eliminating the practice of burning.
5- Post-harvest management to prevent maize production losses
6- Using rain water to improve below-subsistence and subsistence families' productive systems by implementing rain water harvesting and efficient irrigation technologies.

7- Establishment of improved, rust and drought-resistant coffee hybrids
8- Adaptation and diversification of the shade canopy structure-architecture with leguminous arboreal, fruit and timber plants with greater resiliency to the climate conditions forecasted for the region.
9- Adaptation of coffee plant spatial arrangement and architecture to climate change effects forecasted for the region.
10- Coffee nutrition (fertilization) management in the agroforestry system.
11- Coffee pest and disease management, particularly rust, according to climate projections and anomalies for the region, such as increased temperature and more severe droughts.
12- Establishment of productive cacao clones resistant to the main diseases (moniliasis and Mazorca Negra) and with good quality grains.
13- Shade canopy structure-architecture adaptation and diversification with plants and trees (legumes, fruit and timber trees) appropriate for the climate conditions forecasted for the region.
14- Adaptation of cacao tree architecture to prevent the effects of climate change using new shaping and maintenance pruning criteria.
15- Management of nutrition (fertilization) needs of the agroforestry system with cacao
16- Cacao pest and disease management in accordance with climate projections and anomalies f for the region.
17- Sustainable production diversification and intensification in sustainable vegetable gardens, including vines, roots and tubers.
18- Agrobiodiversity diversification and creation of a favorable microclimate in the productive systems.
19- Backyard poultry production based on homemade feeds.
20- Use of rain water to improve the resilience of below-subsistence and subsistence families' productive systems by implementing efficient rain water harvesting and irrigation technologies.
21- Strengthening the resilience of small farmers' livelihoods by adding value to cacao production.
22- Strengthening the resilience of small growers' livelihoods by adding value to coffee production.

Component 2. Supporting efficient water management for agriculture to reduce the impact of increased water scarcity.

- Product 2.1. Community-led Water Management Plans developed and implemented at micro-basin level to promote climate resilience and enhance economic productivity.
- Product 2.2. Degraded landscape restored to improve critical ecosystems services for water resource provision and regulation.
- Product 2.3. Local water collection and irrigation farm systems implemented to secure water supply for resilient livelihoods

23- Protecting forests for water supply (protection of 150 hectares).
24- Forest management for forest and water production (100 hectares).
25- Agroforestry systems for water provision (13,000 hectares of cocoa and coffee).

26- Utilizing rain water to improve below-subsistence and subsistence families' productive systems by implementing rain water harvesting and efficient irrigation technologies.

Component 3. Improved enabling conditions for climate resilient livelihoods.

- Product 3.1. Institutional systems strengthened to govern climate resilient initiatives at national and local level.
- Product 3.2. Knowledge transfer and awareness raising among all level institutions strengthened.

27- Strengthening capacities for access to climate information as the basis for adaptation planning.

The first step in the prioritization process was the selection of the criteria that will be used. For this purpose, a workshop was conducted with watershed management specialists from INAB, MAGA, and MARN. The geospatial model ranked the micro-basins in high and low priority for the implementation of project activities. Based on this, 14 micro-basins were selected (Table 1).

The practices mentioned above are summarized in Table 2 as: extensions of basic grains, agroforestry systems, coffee and cocoa, and they will be implemented by the project as is shown in Table 1:

Table 1. Areas of intervention per Micro-basin in Ha

No.	Micro-basin	Basic grains (ha) /Includes one unit of family Gardens per 1 Ha Basic Grains	Agroforestry with incentives and GCF Support (ha)	Forest incentives (ha)	Coffee (ha)	Cacao (ha)	Total area of implementation (ha)
1	Boloncó	74	938		0	0	1,012
2	Cahabón	835	3,822		330	808	5,795
3	Chixoy o Negro	370	1,254		250	320	2,194
4	Grande de Zaca	102	115		0	0	217
5	Grande o Jocotá	553	647	282	370	0	1,852
6	Matanzas	53	710		110	40	913
7	Olopa	12	85		60	0	157
8	Polochic	449	2,665		318	110	3,542
9	San José	88	41		0	0	129
10	Santo Tomas	50	28		0	0	78
11	Sarstún	78	1,955		0	270	2,303
12	Shusho	30	20		0	0	50
13	Shutaque	61	45		0	0	106
14	Zapote	84	437		370	0	891
TOTAL		**2,839**	**12,762**	**282**	**1,808**	**1,548**	**19,239**

Table 2. Short description for each adaptation measure.

Adaptation measure	Short description
1. Basic Grains Agroforestry system	There is a change from agricultural system to agroforestry system, 830 trees per ha (Gliricidia sepium) will be implemented. Use of conservation tillage, improved drought-resistant and open pollination basic grain seeds and burned practices will be eliminated.
2. Agroforestry / Forest incentives Reforestation and conservation	Reforestation by enrichment of native species (76 trees per ha) to complete the 276 trees per ha for forest incentives and conservation of 282 ha of forest.
3. Coffee Improve production system	Coffee pest and disease management, particularly rust. Establishment of improved, rust and drought-resistant coffee hybrids. Fertilization management and diversification of the shade canopy structure-architecture.
4. Cacao Improve production system	Establishment of productive cacao clones resistant to the main diseases (moniliasis and Mazorca Negra) and with good quality grains. Fertilization management and Adaptation of cacao tree architecture.

7. Other relevant aspects are:

- **Greenhouse gases considered.** The estimation of emissions for this project considers the sequestration, reduction and or avoidance that result from the implementation of the above six proactive modules. It considers sources and sinks from carbon dioxide (C02), Methane (CH4) and Nitrous Oxide (N2O) gases which are presented as CO2 equivalent. GWP for Methane is 25 and for Nitrous Oxide is 298.
- **Pools considered:** Assessement of carbon pool changes are based on above ground biomass, below ground biomass, soil, deadwood and litter. For livestock enteric and manure management sources/sinks are incorporated.
- **Timeframe:** The EX-ACT differentiates between two time periods. First is the implementation phase, the period during which project activities are carried out and second is the capitalization phase, period where project benefits are still occurring because of the activities performed by the project. Given the typology of activities proposed under this project, the analysis considers a 20-year period, which is in line with IPCC recommendation for considering the timeframe between transitions states of natural systems and the period necessary to reach a new equilibrium for carbon stocks. Therefore, the physical implementation of the project consists of 7 years, the sequestration will continue to capitalize for 13 more years to reach the 20-year period. In the specific case of soil organic carbon, a constant rate over a period of 20 years from the year of planting to reach the new equilibrium is assumed. The analysis further assumes the dynamics of change (from without (BAU) to “with project”) to be linear over the duration of the project.

4. Modeling in Ex-Act tool

8. The first step in the analysis was to identify which Ex-Act module was best fit to evaluate each of the activities proposed under each of the productive modules as well as the emission factors that were going to be used either tier 1 (default) or tier 2. Table 2 summarizes the modelling for each of the module for their accounting in Ex-Act

This is the baseline and corresponds to a description of expected conditions in the project boundaries in the absence of project activities, we often refer to the without project. Furthermore, specific technical conditions *with and without project* are also considered for the project situations. These are discussed in detail in the succeeding sections.

Table 3: Characterization of the analysis in the Ex-Act tool

Module	Area (Ha)	Current land use	Assumptions Without project (BAU)	Assumptions With project	EXACT Module	Reference sources
1. Basic Grains	2,839	Annual cropping with burned practices and no conservation tillage practice.	Annual cropping with burned practices and no conservation tillage practice. Degradation will continue	Agroforestry system planted in entire area 830 trees/ha. Use of conservation tillage Improved agronomic practices will be implemented	LUC Other Land Use Change: 2.3 Initial use: Annual Crop Final use: agroforestry system with perennial trees. *The agroforestry system was defined as parkland due to the density	IPCC 2006 Volume 4 Annual/perennial systems Chapter 8 Agriculture of volume in mitigation of the 4th assessment report (smith et. al 2007)
2. Agroforesty / Forest incentives	12,762	Forest lands	Degraded Forest Lands	Reforestation by enrichment of native species (76 trees/ha) to complete the 276 trees/ha for forest incentives in 6,899ha. It is assumed that only 15% of the total ha is reforested due to the low density of trees	LUC Reforestation: 2.2 Previous land use: Forest zone Perennial/Tree Crop (>10 yrs)	Chapter 2 Generic Methodology Applicable to Multiple land use categories The difference between initial and final biomass carbon pools is used to calculate carbon stock change from land-use conversion

	282			Conservation of 282 ha of forest/ avoid deforestation rate 0.5% annual	LUC Deforestation: 2.1 Initial use: Forest Zone Final use after deforestation: Annual Crop	LUC Chapter 4 Forest land
3. Coffee	1808	Coffee with problems of pest and disease particularly rust	Coffee with problems of pest and disease particularly rust will be more severe It will affect 60% of above ground growth rate (tC/ha/year) 10% of the total ha will change to annual crop	The problems of pest and disease it is expected to be controlled. Better yields and no land use change.	LUC Other Land Use Change: 2.3 Initial use: Agroforestry Final use: Annual crop Crop production: 3.2.2 Perennial systems remaining perennial systems	Chapter 2, 11 of IPCC 2006 “Generic Methodology Applicable to Multiple Land-Use Categories” and “N2O emissions from managed soils, and CO2 emissions from lime and urea application”
4. Cacao	1548	Cacao with problems of diseases (moniliasis and Mazorca Negra)	Cacao with problems of diseases (moniliasis and Mazorca Negra) will be more severe: It will affect 50% of above ground growth rate (tC/ha/year) 10% of the total ha will change to annual crop	The problems of pest and disease it is expected to be more controlled. Better yields and no land use change.	LUC Other Land Use Change: 2.3 Initial use: Agroforestry Final use: Annual crop Crop production: 3.2.2 Perennial systems remaining perennial systems	

5. Assumptions & Details of Modeling of Climate Resilient Landscape Production Modules

Guatemala has a variety of climates and soil types throughout its territory, and since the priority areas of the project were divided into 14 micro-basin, the analysis of the data was carried out considering the physical and climatic characteristics of each micro-basin as well as the measures of adaptation that they would be carried out in each of them as shown in table 4.

Table 4. Characteristics and adaptation measures of each micro-watershed.

Micro-basin	Dominant soil type	Climate	Basic Grains	Agroforestry / forest incentives	Conser vation	Coffee	Cacao
1 Boloncó	HAC 61%	Tropical moist	45	572			
	LAC 39%		29	366			
2 Cahabón	LAC	Tropical moist	835	3,822		330	808
3 Chixoy o Negro	LAC	Tropical moist	370	1,254		250	320
4 Grande de Zacapa	HAC	Tropical dry	102	115		0	0
5 Grande o Jocotán	LAC	Tropical moist 58%	321	375	164	215	0
		Tropical dry 42%	232	272	118	155	
6 Matanzas	LAC	Tropical moist	53	710		110	40
7 Olopa	LAC	Tropical moist	12	85		60	0
8 Polochic	LAC	Tropical moist	449	2,665		318	110
9 San José	LAC	Tropical dry	88	41		0	0
10 Santo Tomas	HAC	Tropical dry	50	28		0	0
11 Sarstún	HAC	Tropical moist	78	1,955		0	270
12 Shusho	HAC	Tropical dry	30	20		0	0
13 Shutaque	LAC	Tropical dry	61	45		0	0
14 Zapote	HAC	Tropical Moist	84	437		370	0
Total			2839	12762	282	1808	1548

For practicality to represent the way in which data is entered into EXACT, the way in which each adaptation measure is entered into the tool will be described for the total number of hectares for each measure. In reality, 15 EXACTS were carried out to manage the data since the climate and soil type conditions were considered for each micro-basin, but the way to enter the data for each activity was the same. At the end of this section all the results by micro-basin will be presented.

5.1 Adaptation Measure 1. Basic Grains

Objective: Implementing climate resilient agricultural practices and enhancing farmers' livelihoods through the establishment of agroforestry system in annual crops of maize and beans.

Activities: The specific activities that will be carried out are the use of improved drought-resistant and open pollination basic grain seeds, conservation tillage, burned practices will be eliminated and the establishment of 830 trees per ha (Gliricidia sepium).

Assumptions: The *without project* scenario considers that burned practices will continue, no residues management and no improved agronomic practices will be implemented.

Modeling details: The activities under this module represent a Land Use (LU) change from annual crop to establishment of an agroforestry system. Default tier 1 emission factors coefficient were used as provided by Ex-Act.

Entries in Ex-Act

Modeling of the land use changed of the 2839 hectares was managed as follows:

(I) *2477 ha of annual crop to Perennial/Tree Crop (Agroforestry system*).
(II) Without project it will be fire use and no improved agronomic practices will be implemented.

Step by Step Ex-ACT entries:

Land use change: Module 2.3 Other Land Use Changes.

2.3. Otros cambios en el uso de la tierra													
Rellene con su descripción	Uso de la tierra inicial		Uso de la tierra final	Mensaje	o de incendio ? (si/no)	Área transformada (ha) Sin	*	Con	*	Emisiones totales (tCO2-eq) Sin	Con	Balance	Agroforestry system
	Annual Crop	→	Perennial/Tree Crop		NO	0	D	2,839	D	0	-4,716	-4,716	Parkland

Crop production: Module 3.1.1 Annual Systems form other LU or converted to other LU

3.1.1. Sistemas anuales provenientes de otro uso de la tierra o convertidos en otro uso de la tierra (Por favor rellene paso previo 2. CUT)															
		Opciones de manejo		Definiciones?					Rendimiento ?						
Descripción	Temporada agrícola principal	Prácticas agronómicas mejoradas	Manejo de nutrientes	No laboreo y retención de residuos	Gestión hídrica	Aplicación de estiércol	?	Gestión de residuos	Rendimien ? (t/ha/añ	Área (ha) Inicio	Sin	Con	Emisiones totales (tCO2-eq) Sin	Con	Balance
Cultivo annual después de def	Default	?	?	?	?	?		Please select		0	0	0	0	0	0
Convertido en A/R	Default	?	?	?	?	?		Please select		0	0	0	0	0	0
Cultivo annual después de UT r	Default	?	?	?	?	?		Please select		0	0	0	0	0	0
Convertido en OCUT	Beans & pulses	No	No	No	No	No		Burned		2,839	2,839	0	9,380	1,641	-7,738

Crop production: Module 3.2.1 Perennial systems from other LU or converted to other LU

3.2 Sistemas perennes (Agroforestales, huertos, cultivos arbóreos...)								
3.2.1. Sistemas perennes de otros CUT o convertidos a otros CUT (por favor, rellene previamente el paso 2. CUT)								
Descripción	Quema de residuos o biomasa	Rendimien ? (t/ha/añ	Area (ha) Inicio	Sin	Con	Emisiones totales (tCO2-eq) Sin	Con	Balance
Cultivo perenne después de la deforestación	NO		0	0	0	0	0	0
Convertido en A/R	NO		0	0	0	0	0	0
Cultivo perenne después de UT no forestal	NO		0	0	2,839	0	-98,267	-98,267
Convertido en OCUT	NO		0	0	0	0	0	0

5.2 Adaptation Measure 2. Agroforestry/forest incentives

Objective: Degraded landscape restored to improve critical ecosystems services for water resource provision and regulation.

Activities: Reforestation by enrichment of native species (76 trees per ha) to complete the 276 trees per ha for forest incentives in 12,762 ha and conservation of 282 ha of forest.

Assumptions: The *without project* scenario considers that no reforestation practices will be implemented and the deforestation rate of 0.5% will continue in the 282 ha of forest. The whit project scenario assumes that 15% of the 12,762 ha will be reforested (It is assumed that only 15% of the total ha is reforested due to the low density of trees) and the 282 ha of forest will be preserved.

Modeling details: The activities under this module represent a Land Use Change (LUC) from deforestation avoided and reforestation. Default tier 1 emission factors coefficient were used as provided by Ex-Act.

Entries in Ex-Act

Modeling of the land use changed of the 12,762 hectares was managed as follows:

(I) *12,762 ha *.15= 1914.3 ha* will be reforested in LUC section.
(II) 282 ha without project will be deforested in LUC section.

Step by Step Ex-ACT entries:

Land use change: Module 2.2 Afforestation and reforestation

2.2. Afforestation and Reforestation									
? AEZ map	Zone 1 = Tropical rain forest	Zone 2 = Tropical moist deciduous forest	Zone 3 = Tropical dry forest				Zone 4 = Tropical shrubland		
Type of vegetation that will be planted	Fire Use? (y/n)	Previous land use	Area that will be afforested/reforested Without	*	With	*	Total Emissions (tCO2-eq) Without	With	Balance
Forest Zone 1	NO	Perennial/Tree Crop (>10 yrs)	0	D	1,914	D	0	-698,526	-698,526
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0

Land use change: Module 2.1 Deforestation

2.1. Deforestation														
? AEZ map	Zone 1 = Tropical rain forest		Zone 2 = Tropical moist deciduous forest	Zone 3 = Tropical dry forest					Zone 4 = Tropical shrubland					
Type of vegetation that will be deforested	HWP# (tDM/ha)	Fire Use? (y/n)	Final use after deforestation	Forested area (ha) Start	Without	*	With	*	Deforested area (ha) Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Forest Zone 1	0	NO	Annual Crop	282	272	D	282	D	10	0	7,561	0	-7,561
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0

5.3 Adaptation Measure 3. Coffee

Objective: Strengthen the resilience of small growers' livelihoods by establishing improved, rust and drought-resistant coffee hybrids.

Activities: Coffee pest and disease management, particularly rust. Establishment of improved, rust and drought-resistant coffee hybrids. Fertilization management and diversification of the shade canopy structure-architecture.

Assumptions: The *without project* scenario considers that Coffee with problems of pest and disease particularly rust will be more severe, it will affect 60% of above ground growth rate (tC/ha/year) and 10% of the total ha will change to annual crop. The whit project scenario assumes that the problems of pest and disease it is expected to be controlled, better yields and no land use change will occur.

Modeling details: The activities under this module represent a Land Use Change (LUC) from perennial tree crop to annual crop and in the section of Crop production, perennial systems remaining perennial systems. Default tier 1 emission factors coefficient were used as provided by Ex-Act.

Entries in Ex-Act

Modeling of the land use changed of the 1808 hectares was managed as follows:

(I) *1627 ha* will remain as agroforestry system but without project it will affect 60% of above ground growth rate (tC/ha/year).

(II) 181 ha without project will change from agroforestry system to annual crop.

Step by Step Ex-ACT entries:

Land use change: Module 2.3 Other Land Use Changes.

2.3. Other Land Use Changes

Fill with your description	Initial land use		Final land use	Message	Fire Use? (y/n)	Area transformed (ha) Without	*	With	*	Total Emissions (tCO2-eq) Without	With	Balance
	Perennial/Tree Crop (>10 yrs)	→	Annual Crop		NO	181	D	0	D	24,069	0	-24,069
	Select Initial Land Use	→	Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0

Crop production: Module 3.2.2. Perennial systems remaining perennial systems.

3.2.2. Perennial systems remaining perrenial systems (total area must remain constant)

Fill with your description	Agroforestry systems ?	Residue/ biomass burning	Yield ? (t/ha/yr)	Area (ha) Start	Without	*	With	*	Total Emissions (tCO2-eq) Without	With	Balance
cafetal con roya	Shaded perennial-crop systems	NO		1,627	1,627	D	0	D	-196,737	-34,429	162,308
Cafetal con proyecto	Shaded perennial-crop systems	NO		1,627		D	1,627	D	-54,724	-312,709	-257,985

Ground growth rate

Systems	Above-ground Growth rate (t C/ha/yr) Default	Tier 2
Perennial systems from (or to) other LU	Default	Tier 2
Perennial after Deforestation		
Converted to A/R	0.00	
Perennial after non-forest LU		
Converted to OLUC	0.00	
Perennial syst. remaining perennial syst.		
cafetal con roya	2.43	1.5
Cafetal con proyecto	2.43	

5.4 Adaptation Measure 4. Cacao

Objective: Strengthen the resilience of small growers' livelihoods by establishing cacao clones resistant to the main diseases (moniliasis and Mazorca Negra).

Activities:

Cacao disease management, particularly moniliasis and mazorca negra. Establishment of improved and drought-resistant cacao hybrids. Fertilization management and diversification of the shade canopy structure-architecture.

Assumptions: The *without project* scenario considers that Cacao with problems of diseases (moniliasis and Mazorca Negra) will be more severe, it will affect 50% of above ground growth rate (tC/ha/year) and 10% of the total ha will change to annual crop. The whit project scenario assumes that the problems of diseases it is expected to be controlled, better yields and no land use change will occur.

Modeling details: The activities under this module represent a Land Use Change (LUC) from perennial tree crop to annual crop and in the section of Crop production, perennial systems remaining perennial systems. Default tier 1 emission factors coefficient were used as provided by Ex-Act.

Entries in Ex-Act

Modeling of the land use changed of the 1548 hectares was managed as follows:

(I) *1393 ha* will remain as agroforestry system but without project it will affect 60% of above ground growth rate (tC/ha/year).

(II) 155 ha without project will change from agroforestry system to annual crop.

Step by Step Ex-ACT entries:

Land use change: Module 2.3 Other Land Use Changes.

2.3. Other Land Use Changes											
Fill with your description	Initial land use		Final land use	Message	Fire Use? (y/n)	Area transformed (ha)				Total Emissions (tCO2-eq)		Balance
						Without	*	With	*	Without	With	
	Perennial/Tree Crop (>10 yrs)	→	Annual Crop		NO	155	D	0	D	20,612	0	-20,612

Crop production: Module 3.2.2. Perennial systems remaining perennial systems.

Fill with your description	Agroforestry systems	Residue/ biomass burning	Yield (t/ha/yr)	Area (ha) Start	Without	*	With	*	Total Emissions (tCO2-eq) Without	With	Balance
Cacao con Monialisis y Mazorca negra	Shaded perennial-crop systems	NO		1,393	1,393	D	0	D	-193,265	-33,821	159,443
Cacao con proyecto	Shaded perennial-crop systems	NO		1,393		D	1,393	D	-46,854	-267,735	-220,881

3.2.2. Perennial systems remaining perrenial systems (total area must remain constant)

Ground growth rate

Systems	Above-ground Growth rate (t C/ha/yr) Default	Tier 2
Perennial systems from (or to) other LU		
Perennial after Deforestation		
Converted to A/R	0.00	
Perennial after non-forest LU		
Converted to OLUC	0.00	
Perennial syst. remaining perennial syst.		
Cacao con Monialisis y Mazorca negra	2.43	1.7
Cacao con proyecto	2.43	

6. Results

Net carbon balance. The net carbon balance quantifies GHGs emitted or sequestered resulting from the project compared to the “without project” (BAU) scenario. In this case results indicate that the project constitutes a carbon sink of -345, 981 million tCO2-eq in 7 years and -988,260 million tCO2-eq in 20 years. This indicates that the project can also have a contribution in mitigation which complements the adaptation and resilience objectives sought by the project.

Table 5. Mitigation potential by Micro-watershed

									Balance in Ton CO2eq			
Micro-basin	Dominant soil type	Climate	Basic Grains	Agroforestry / forest incentives	Conser vation	Coffee	Cacao		x ha/year	1 year	7 years	20 years
1 Boloncó	HAC 61%	Tropical moist	45	572				Results	-12.4	-1624	-11368	-32480
	LAC 39%		29	366					-12.3	-1030	-7210	-20600
2 Cahabón	LAC	Tropical moist	835	3,822		330	808		-5.9	-15029	-105203	-300580
3 Chixoy o Negro	LAC	Tropical moist	370	1,254		250	320		-5.1	-5733	-40131	-114660
4 Grande de Zacapa	HAC	Tropical dry	102	115		0	0		-3.8	-458	-3206	-9160
5 Grande o Jocotán	LAC	Tropical moist 58%	321	375	164	215	0		-3.4	-2581	-18067	-51620
		Tropical dry 42%	232	272	118	155			-2.9	-1593	-11151	-31860
6 Matanzas	LAC	Tropical moist	53	710		110	40		-7.9	-2453	-17171	-49060
7 Olopa	LAC	Tropical moist	12	85		60	0		-5.3	-445	-3115	-8900
8 Polochic	LAC	Tropical moist	449	2,665		318	110		-7.1	-9161	-64127	-183220
9 San José	LAC	Tropical dry	88	41		0	0		-2.9	-277	-1939	-5540
10 Santo Tomas	HAC	Tropical dry	50	28		0	0		-3.1	-166	-1162	-3320
11 Sarstún	HAC	Tropical moist	78	1,955		0	270		-9.4	-6029	-42203	-120580
12 Shusho	HAC	Tropical dry	30	20		0	0		-3.2	-114	-798	-2280
13 Shutaque	LAC	Tropical dry	61	45		0	0		-3.1	-211	-1477	-4220
14 Zapote	HAC	Tropical Moist	84	437		370	0		-4.8	-2509	-17563	-50180
Total			2839	12762	282	1808	1548		- 93	- 49,413	- 345,891	- 988,260

Sensitivity analysis. This is an ex ante analysis and was done under conservative assumptions to minimize the overestimation of benefits. It will be important to closely monitor the assumptions made during project implementation to truly assess the impact of the project on the ground.