AGROFORESTRY AND FOREST RESTORATION FOR ECOLOGICAL CONNECTIVITY, POVERTY REDUCTION AND BIODIVERSITY CONSERVATION IN CERRO SAN GIL, CARIBBEAN GUATEMALA.

Document Prepared By FUNDAECO and AGRESTA

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Table of Contents

1 Project Details 4
1.1 Summary Description of the Project and its Implementation Status 4
1.2 Sectoral Scope and Project Type 5
1.3 Project Proponent 5
1.4 Other Entities Involved in the Project 5
1.5 Project Start Date 6
1.6 Project Crediting Period 6
1.7 Project Scale and Estimated GHG Emission Reductions or Removals 6
1.8 Description of the Project Activity 7
1.8.1 Phases of the Project 8
1.8.2 Plantation systems and species selected. 10
1.8.3 Spacing and plantation density 11
1.8.4 Seedling procurement 12
1.8.5 Site preparation and planting 12
1.8.6 Water Supply 13
1.8.7 Plantation maintenance 13
1.8.8 Plant protection 14
1.8.9 Management and final disposal of wastes 14
1.9 Project Location 14
1.10 Conditions Prior to Project Initiation 19
1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks 23
1.12 Ownership and Other Programs 24
1.12.1 Project ownership 24
1.12.2 Emissions Trading Programs and Other Binding Limits 24
1.12.3 Other Forms of Environmental Credit 24
1.12.4 Participation under Other GHG Programs 24
1.12.5 Projects Rejected by Other GHG Programs 24
1.13 Additional Information Relevant to the Project 25
2 Application of Methodology 27
2.1 Title and Reference of Methodology 27
2.2 Applicability of Methodology 27
2.3 Project Boundary 30
2.4 Baseline Scenario 32
2.5 Additionality 36
2.6 Methodology Deviations 36
3 Estimated GHG Emission Reductions and Removals 37
3.1 Baseline Emissions 37
3.2 Project Emissions 39
3.3 Leakage 58
3.4 Estimated Net GHG Emission Reductions and Removals 60
4 Monitoring 62
4.1 Data and Parameters Available at Validation 62
4.2 Data and Parameters Monitored 71

4.3 Monitoring Plan 78
5 Environmental Impact 85
6 Stakeholder Comments 87
7 Achieved GHG Emission Reductions and Removals 88
7.1 Data and Parameters Monitored 88
7.2 Baseline Emissions 90
7.3 Project Emissions 90
7.4 Leakage 96
7.5 Net GHG Emission Reductions and Removals 96

Project Details

1.1 Summary Description of the Project and its Implementation Status

The project "Agroforestry and Forest Restoration for Ecological Connectivity, Poverty Reduction and Biodiversity Conservation in Cerro San Gil, Caribbean Guatemala" is a grouped project for the afforestation, reforestation and/or revegetation (hereafter referred to as "ARR") of lands in Guatemala. The project started in 2013 and its main goals are: improve connectivity and / or continuity of forest cover without negative effects on biodiversity at the community and landscape level; improving food security and rural incomes; improving the conditions of conservation and protected area management at the regional level, including better community resilience to climate change; climate change mitigation; recover watersheds; reduce erosion; and generate sustainable incomes for farmers.

The project proponent of this grouped project is an international private fund "Livelihoods Fund" (LIVELIHOODS), co-managed by private companies (Danone, Crédit Agricole, CDC Climat, Schneider Electric, Michelin, Groupe La Poste, Hermès, Voyageurs du Monde, Firmenich and SAP).

The project implementing partner, of the first project activity instances, is the Guatemalan NGO "Fundación para el Ecodesarrollo y la Conservación" (FUNDAECO). FUNDAECO is a private, non-political and not-for-profit organization dedicated to Nature Conservation and Sustainable Community Development. It was created in 1990, and has a history of more than 20 years of environmental work in Guatemala and Central America. FUNDAECO is registered as a co-managing partner in the National Protected Areas Council (CONAP).

First project activity instances pretend the afforestation, reforestation and restoration of 4,000 ha[1] using four different planting systems: mixed forest trees plantations, mixed fruit tree family orchards, rubber tree plantations and agroforestry systems in degraded lands. Project will be implemented in more than 20 rural communities located in the buffer zone, multiple use zone and zones of influence of the Cerro San Gil Protected Area, Department of Izabal. Project will consist in ARR activities in small lands owned by local people/communities. Local people, with the support of FUNDAECO, will be in charge of the implementation of project activities. This type ARR projects promotes the sustainable development in the Region, brings benefits to the communities, improves connectivity and / or continuity of forest cover without negative effects on biodiversity at the community and landscape level and protects the existent natural resources. The land uses previous to the project activity are croplands and grasslands in degraded lands. Potential project leakage and non-permanence risk factors will be monitored and managed by FUNDAECO following the guidelines included in this PD&MR document and in the internal project documents.

The annual average GHG removals by sinks, in the first project activity instance (2013-2016), are estimated ex–ante as 39,499.38 tCO_2-e, with a total value over the crediting period of 1,184,981.42 tCO_2-e.

[1] See area of the first project activity instance in section 1.9.

1.2 Sectoral Scope and Project Type

The project has been developed under VCS sectoral scope 14 (Agriculture, Forestry and Other Land Use) and is categorized as the VCS AFOLU category ARR: Afforestation, Reforestation and Revegetation. As abovementioned, the project is a grouped project.

1.3 Project Proponent

Organization name	Livelihoods Fund
Contact person	Mr. Jean-Pierre RENNAUD
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1.4 Other Entities Involved in the Project

Organization name	FUNDAECO
Role in the project	First instance´s project developer and implementer (implementing partner)
Contact person	Mr. Marco Vinicio Cerezo Blandón
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Organization name	Agresta S. Coop.
Role in the project	Preparation of project description and advise during the validation process
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1.5 Project Start Date

The start date for the project is August 26, 2013, which corresponds to the date on which Fundaeco started planting the first planting campaign.

1.6 Project Crediting Period

The project crediting period for this grouped project shall be 30 years renewable, beginning on August 26, 2013 and ending on August 25, 2043.

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	X
Large project	

Year	Estimated GHG emission reductions or removals (tCO_2e) (data of the first project activity instance)
2013	5,094.30
2014	29,121.09
2015	60,950.55
2016	65,239.72
2017	64,794.88
2018	64,532.05
2019	64,339.00
2020	64,186.17
2021	64,059.75
2022	63,952.04
2023	63,858.30
2024	63,775.38
2025	63,701.08
2026	63,633.83
2027	63,572.42
2028	63,515.96
2029	63,463.71
2030	63,415.11

Year	Estimated GHG emission reductions or removals (tCO_2e) (data of the first project activity instance)
2031	63,369.71
2032	-2,071.64
2033	-87,227.36
2034	-224,389.61
2035	7,437.68
2036	59,001.61
2037	58,766.96
2038	58,625.37
2039	58,518.31
2040	58,431.17
2041	58,357.21
2042	20,956.66
Total estimated ERs	1,184,981.42
Total number of crediting years	30
Average annual ERs	39,499.38

1.8 Description of the Project Activity

This project will seek to promote ecological connectivity, poverty reduction and biodiversity conservation at the landscape level in Caribbean Guatemala, through the establishment of agroforestry systems and the restoration of forests in communities located close to the remaining natural forests around the protected area of Cerro San Gil, Izabal, Guatemala. By reducing pressures on the remaining natural forests, the project will also contribute to improved Protected Area Management and biodiversity conservation at the regional level, and will enhance ecological connectivity in this vital migratory funnel for over 120 species of neo-tropical migratory birds.

The main goals of the project are: a) improve connectivity and / or continuity of forest cover without negative effects on biodiversity at the community and landscape level; b) improving food security and rural incomes; c) improving the conditions of conservation and protected area management at the regional level, including better community resilience to climate change; d)

climate change mitigation; e) recover watersheds; f) reduce erosion; and g) generate sustainable incomes for farmers.

This project seeks to establish, in the first activity instances, 4,000 hectares[2] of agroforestry and forest plantations in approximately 23 rural communities (maya-q'ueqchi and mestizos) located in the buffer zone, multiple use zone and zones of influence of the Cerro San Gil Protected Area.

Three main actors will be part of this project: LIVELIHOODS as project proponent; FUNDAECO, a national NGO participating as project implementing partner, supporting local farmers in the effective project implementation and developing management plans; and local farmers, owners of the project area and responsible for planting and maintenance.

Beneficiaries will have the opportunity to be credited by the own financial mechanism of the project and the national forest incentive fund granted by the State. They will be allowed to commercialize in the medium and long term the various services and ecosystem provisioning products obtained from the hectares planted.

The project will bring to local communities all necessary training, tools and inputs to plant agroforestry systems and forests. Actions will include training for nursery management, for plantation, for maintenance, purchase of seedlings, tools and inputs, payment for transportation and logistics.

This grouped project is located in Izabal Department which is covered by the FCPF REDD+ program of Guatemala[3]. The project is not located within a jurisdiction covered by any other jurisdictional REDD+ program.

A typical instance under this grouped project comprises an afforestation, reforestation and/or revegetation activity of lands except wetlands. Instances may use different measures / technologies to convert the non-forest land into forest land and/or to revegetate the project area. Nevertheless, the main steps to implement activities will be: Logistics organization; Training; Site selection; Species selection and seedling preparation; Planting (site preparation, planting, etc.) and Maintenance.

The description of the first project activity instance is included, as an example, in the following sections.

1.8.1 Phases of the Project

Phase 1

Identification of areas to be restored

Through GIS and field visits, an analysis is made by FUNDAECO of the areas that have been deforested for agriculture and livestock before 2001. From this identification of change of land use dynamic, areas with potential to be restored are mapped, and it is identified the zoning of the

[2] See area of first project activity instance in section 1.9.
[3] Guatemala is a REDD+ country in the Forest Carbon Partnership Facility (FCPF) of The World Bank

protected area where the project will impact, to suit the management regulations as set out in the zoning of the protected area.

Design of project restoration models

After the identification of deforested areas FUNDAECO designs the different plantation systems to be implemented in the project (agroforestry, rubber plantations, forest plantations and orchards).

Phase 2

Implementation of the project

For the implementation of the project the objectives and challenges that would entail getting involved in the project were made public, in local communities and with private owners, in awareness campaign. To have the expected success, there is a group of trained professionals giving support and technical advisory services to farmers, during all phases of the establishment of the project.

After the identification of stakeholders interested in the project FUNDAECO started activities for the implementation: land mapping, contracts with landowners, plant/seedlings acquisition (plant purchase or establishment of community nurseries), purchase of tools and agricultural inputs, and training for the establishment and management of plantations.

30 years after project start it will have contributed to improve the management of the protected area, conservation of biodiversity at regional level and ecological connectivity in the forests of the region.

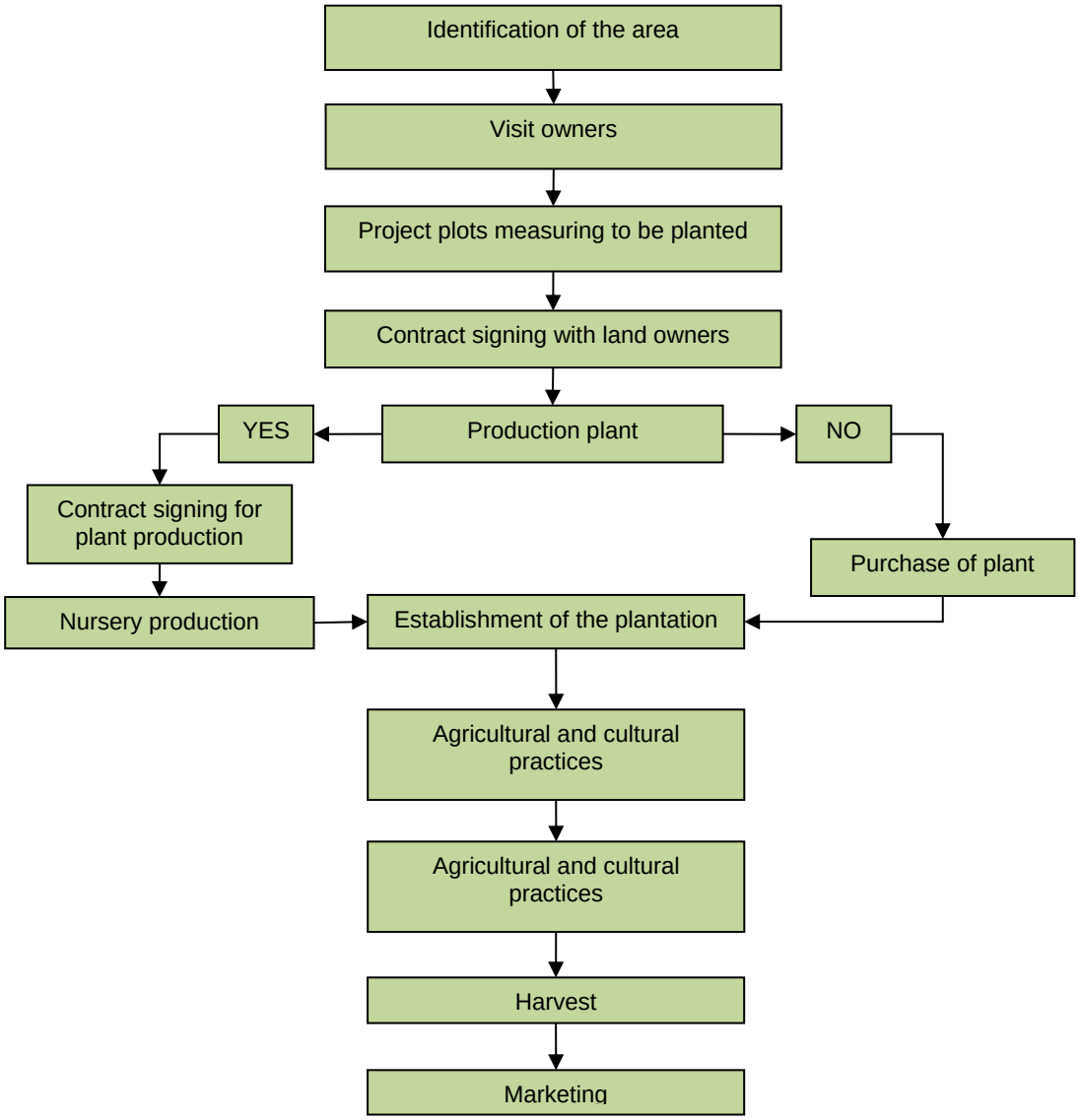

Figure 1. Activity flow diagram

1.8.2 Plantation systems and species selected.

Under this first activity instance, four different agroforestry system and forest plantations will be established.

a) Rubber Tree Plantations (*Hevea brasiliensis*)

b) Mixed Tree Species Forest Plantations

c) Mixed Fruit Tree Family Orchards (Tangerine -*Citrus reticulata*- ; Lemon -*Citrus limon*-; and Rambután- *Nephelium lappaceum*-)

d) Agroforestry systems

The main tree species used in all forest plantations and agroforestry systems are the following:

- Spanish cedar (*Cedrella odorata*);
- Laurel (*Cordia alliodora*);
- Laurel Negro (*Cordia gerascanthus*);
- San Juan (*Vochysia guatemalensis*);
- Santa Maria (*Calophyllum brasiliense var Relcoi*);
- Mahogany (*Swietenia macrophylla*);
- Teak (Tectona grandis);
- Gmelina “Melina” (*Gmelina arbórea*);
- Palo Blanco (*Tabebuia donell-smithii rose*);
- Ramón (*Brosimum allicastum*);
- Barillo (*Symphonia globulifera*);
- Sangre (*Virola spp*),

These species were selected in order to maximize the output in terms of Carbon Sequestration; Market Demand; Income delivery; and Food Security.

Agroforestry systems include:

a) Shade grown Black Pepper (*Piper nigrum*) under Nitrogen Fixing Trees (*Gliricidia sepium*),

b) Mixed Tree Species Forest Plantations interspaced with coffee (*Coffea arabiga*) or cacao (*Theobroma cacao*),

c) Mixed Tree Species Forest Plantations interspaced with Cardamom (*Eleltarea cardamomum*).

1.8.3 Spacing and plantation density

Project area was planted using different spacing depending on the selected planting system, as summarized in the following table.

Table 1. Planting spacing and density

Planting system	Species/group of species	Density (tree/ha)	Spacing (m x m)
Rubber tree plantation	Rubber	510	7 x 2.8 or 6 x 3
Forest plantations	Mixed Forest	1111	3 x 3
Agroforestry systems	Black pepper	1111	3 x 3
	Shadow trees (for Coffee, Cacao and Cardamom)	1111 or 277	3 x 3 or 6 x 6
	Coffee	3333	1.5 x 2
	Cacao	1111	3 x 3
	Cardamom	1111	3 x 3
Orchards	Orchard	204	7 x 7

1.8.4 Seedling procurement

During the first plantation campaign (2013/2014), 100% saplings were purchased externally, in order to accelerate the establishment of the initial plantations. In the following plantation campaigns (2014/2015 and 2015/2016) all saplings were produced in nurseries managed by farmers under FUNDAECO's supervision. For the project implementation seedlings are purchased in this local nurseries.

Only certified plant material from known certified improved source was used. Only healthy seedlings with a height ranging between 30 and 50 cm were planted. AII seedlings showing one of the following weaknesses before planting were discarded:

- Broken, skinned, or weak stems.
- Dry leaves, needles or roots.
- Presence of a fungus or any other disease.
- Seedlings with leave/needle coloration that indicate nutrient deficiency.

1.8.5 Site preparation and planting

Site preparation

Planting area was slashed, using cutting tools like machetes or guarizama, hoes and rakes to pile waste.

Where possible the use of fire for site preparation was avoided, leaving plant residues between the planting rows in order to promote decomposition. Fire for site preparation was only used in the project implementation in areas where it is a common practice in pre-project activities (mainly in agriculture).

Hole digging

20 centimeters wide and 30 centimeters deep holes were made. This feature helps the plant to have an area for root growth in the first months, allowing better use of nutrients and water absorption.

When the hole digging was carried out the topsoil was removed to place it on the bottom of the hole when planting. The surface layer should be placed near the roots so that they can quickly take advantage of the nutrients it contains.

Planting

Seedlings were contained in plastic bags, before planting bags they were removed and recycled. The seedling were manually centered in the hole and then back filled with topsoil. The sides of the hole were filled with the substrate, ensuring that no air voids remain and that substrate stay firmly compacted. Before planting it was verified that the holes were not waterlogged.

In this first project activity instances planting was performed in three plantation campaigns y four years (2013-2014, 2014-2015 and 2015-2016) using the four described planting systems.

Replanting

Plant survival is evaluated within 90 days of the plantation. Where the mortality is higher than 10% replanting is needed, following the same procedure described before. Survival evaluations are performed also the within 2 years of the plantation.

1.8.6 Water Supply

Surface water extracted using traditional methods was used for the project. Irrigation was destined for seedlings in nurseries. An irrigation schedule for critical months (March and April) was developed where it was necessary to prevent seedlings mortality in the field. Therefore, no significant amounts of water were needed for the project implementation.

1.8.7 Plantation maintenance

Weeding

The weeding cycle mainly depends on the on-site vegetation and the weather. Whenever plants are competing with weeds they have been eliminated. In general two types of weeding are applied:

- Strip weeding, hoeing is conducted along the planting lines with a 1 m width; and
- Weeds will be pulled out by hand 20 cm around each seedling to make sure that the plant is not damaged;

Depending on the site conditions, 1 - 2 weeding cycles are necessary during the planting season and 1-2 cycles during the dry season.

Pruning

This activity will take place if trees have very notorious deformations or if there is too much interaction between individuals, affecting their development.

1.8.8 Plant protection

Fire control

3 meters width perimeter barriers firewall in planting area will be fitted where needed, as well as intermediate barriers within the plantation. Intermediate barriers may be used for transportation.

Permanent and temporary crews for preventing and fighting forest fires will be supported.

There will be permanent patrols in this area and with higher frequency during the period of greatest risk of fire.

Pest and diseases control

Periodic reviews will be conducted on the plantation to check the status of the plant, placing special emphasis on cricket, Hymenoptera, *Hypsipyla grandella* and rodents.

1.8.9 Management and final disposal of wastes

In the project implementation products of synthetic origin are used where necessary (herbicides, fungicides and fertilizers) according to forest management plans. Applications are performed far from sources of water. It is important to mention that the plantation plots are located away from the living areas so the people and natural ecosystems were not affected by the actions of the project.

Solid waste are classified according to their origin (plastic, paper, organic) and then be placed as appropriate. Wastes plastic and paper are transported to the Puerto Barrios municipal landfill and wastes of organic origin are used in plantations as fertilizer.

1.9 Project Location

The grouped project geographic boundary corresponds to Department of Izabal in Guatemala, including all its municipalities: Livingstón, Puerto Barrios, Morales, Los Amates and El Estor.

The following table and figure show the project boundary area and limits.

Table 2. Project boundary

Department	Municipality	Area (ha)
Izabal	Puerto Barrios	120.250,35
	Livingstón	236.100,40
	El Estor	157.894,18
	Morales	133.042,17
	Los Amates	104.606,67
TOTAL		**751.893,77**

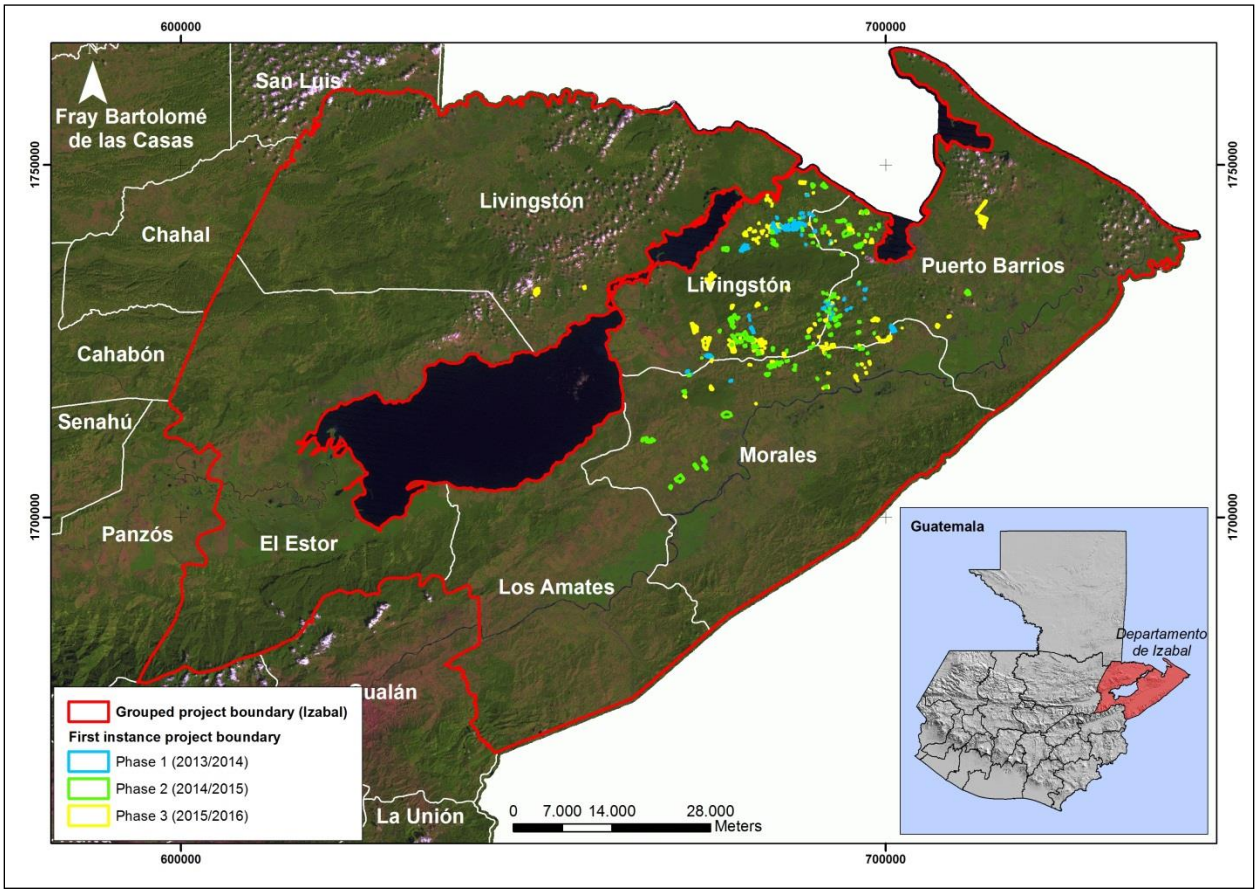

Figure 2. Project boundary

Boundaries geodetic coordinates of the grouped project boundary will be available in *.kml and *.shp files.

In the first project activity instance planted areas boundaries have been determined after planting with a handheld Global Positioning System receiver (GPS). With this information, an eligibility of land assessment has been done considering VCS AFOLU Requirements (sections 3.1.6 and 4.2.1). This study was done based on GPS measurements, satellite images, aerial photographs

and Google earth images, and is available for VVB on request. In this study it has been demonstrated that the project area was not forest before the project start date. Following Section 3.1.6. of the VCS AFOLU Requirement, land eligibility is confirmed because it is demonstrated that project areas were not cleared of native ecosystems to create GHG credits.

The result of the eligibility assessment provides the project boundary of the first instance summarized in the following table.

Table 3. Location of the 1st project instance

Municipality	Rural Community	Number of planted parcels	Area (ha)
Livingston	Barra lampara	2	2.76
	Carboneras	2	14.00
	Cayo Quemado	1	21.61
	Creek Maya	78	46.07
	El Milagro	3	4.35
	El Paraíso	29	142.42
	La Pintada	9	5.82
	Lámpara	65	70.09
	Las Veguitas	5	15.03
	Los Angeles	4	13.01
	Los Laureles	18	18.59
	Lote 6	7	75.17
	Monte Sión	18	55.59
	Punta de Palma	1	20.17
	Quebrada Seca	17	31.53
	Río Blanco	2	1.93
	Río Salado	1	15.08
	San Antonio Seja	4	48.38
	San Marcos	3	13.48
	San Miguelito	1	0.20
	Santa Elena Río Blanco	17	10.60
	Sector A	3	10.62
	Sector B	16	43.62
	Tameja	17	45.48
	Zapotillo	32	23.81
	Total	355	749.40
Morales	Cayuga	7	5.68
	Cerro Azul	3	15.19
	Cimarrón	5	18.26
	Corralitos	1	1.40
	Cucharas	2	5.37

Municipality	Rural Community	Number of planted parcels	Area (ha)
	Cumbre Fría	17	41.38
	Cumbre San José	1	3.50
	El Ciprés	11	105.51
	El Rosario	3	18.84
	El Satélite	4	11.12
	La Pimienta	1	1.90
	Las Jaras	55	80.38
	Los Andes	2	29.99
	Montaña Chiclera	1	4.30
	Naranjito	1	9.65
	Navajoa	2	7.26
	Palestina	12	35.41
	Picuatz	5	10.49
	Santa Bárbara	1	75.01
	Santa Marta	1	14.50
	Valle Nuevo	1	11.50
	Virginia	5	129.82
	Zaragoza	4	7.30
	Total	145	643.76
Puerto Barrios	El Castañal	4	2.96
	El Mirador	4	4.11
	Esperanza del mar	4	23.62
	Las Delicias	2	14.74
	Las Pavas	11	105.44
	Machacas	1	12.08
	Machaquitas	3	27.94
	Manacas	1	12.13
	Punta de Palma	6	20.02
	San Francisco	3	95.25
	San Miguelito	3	10.19
	San Pedro	12	15.82
	San Pedro La Cocona	3	7.56
	Sarita	6	8.37
	Veracruz	1	4.20
	Total	64	364.43
TOTAL		**564**	**1757.59**

Geographic coordinates of each parcel included in the proposed activity are available in Excel, *.kml and *.shp files.

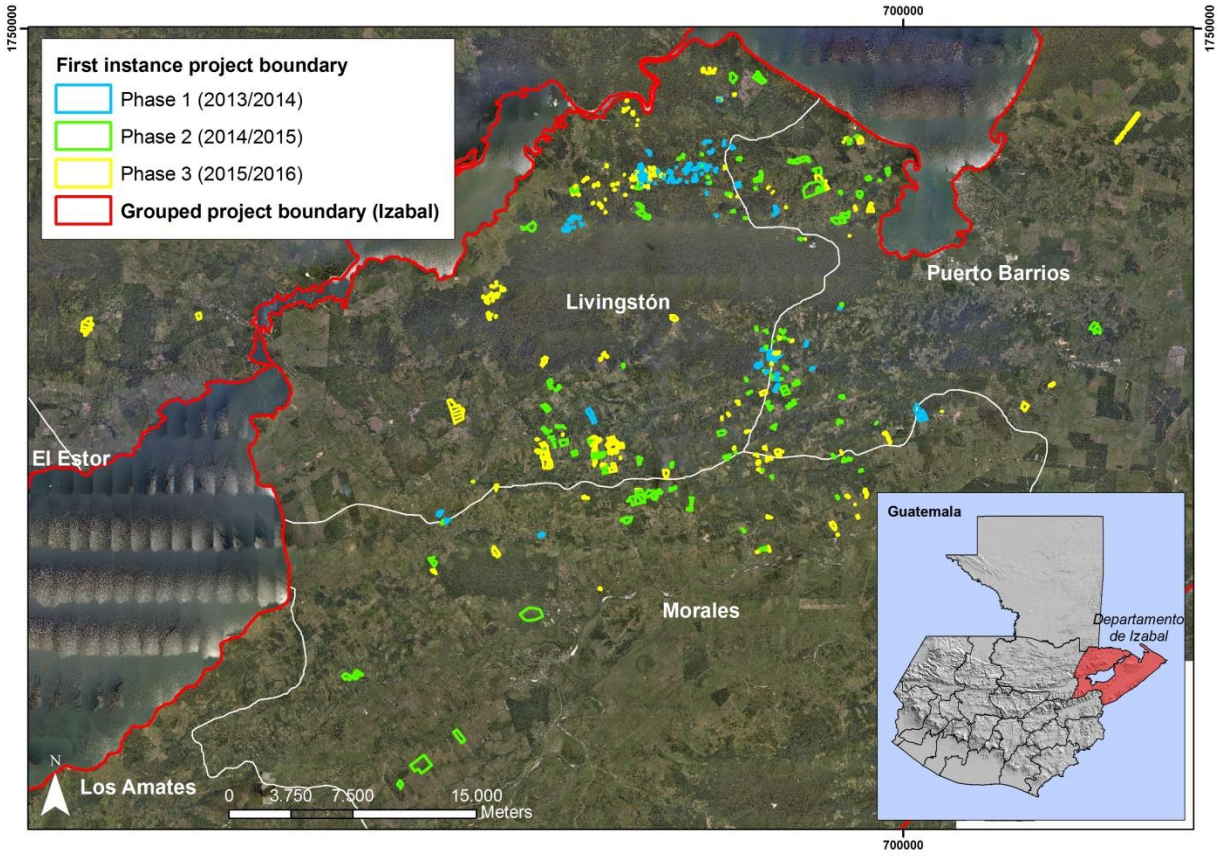

Figure 3. Project boundary of 1st Project activity instance

First project activity instance has been stratified ex-ante based on two criteria: planting year and planting system. As described in section 1.8. the project was implemented in four consecutive years, from 2013 to 2016; and four different plantation systems were considered (Forest plantations, Agroforestry systems, Rubber plantations and Orchards).

Based on the abovementioned two criteria, the following ex ante stratification has been obtained:

Table 4. Stratification of first project activity instance

Planting year	Planting system	Stratum	Area (ha)	Area (%)
2013	Rubber	I	38.90	2%
	Forest plantation	II	63.09	4%
2014	Rubber	III	432.05	25%
	Forest plantation	IV	174.45	10%
2015	Rubber	V	432.43	25%
	Forest plantation	VI	337.18	19%

Planting year	Planting system	Stratum	Area (ha)	Area (%)
2013-14-15	Agroforestry systems (AFS)	VII	81.75	5%
2013-14-15	Orchards	VIII	64.48	4%
2016	All	Z[4]	133.26	8%
TOTAL			1,757.59	100%

1.10 Conditions Prior to Project Initiation

As demonstrated in section 1.9, following section sections 3.1.6 and 4.2.1 of the VCS AFOLU Requirement, project has not been implemented to generate GHG emissions for the purpose of their subsequent reduction, removal or destruction.

The baseline scenario of the total potential project area is the same as the conditions existing prior to the project initiation; therefore the baseline scenario is described in Section 2.4 (Baseline Scenario).

Environmental conditions of the project area

The following description was taken from CONAP, FUNDAECO, TNC, 2006: "Plan Maestro de la Reserva de Manantiales Cerro San Gil. Guatemala" [5]. For a more detailed description, we refer to this document.

Climate

According to Holdridge life zones classification the Reserva Protectora de Manantiales Cerro San Gil (RPMCSG) hosts forests corresponding to Very Humid Tropical Forest (Bmh-T) below 900m and Very Humid Sub-tropical Warm Forest (Bmh-S(c)) between 900 and 1267m.

In accordance with Thornthwaite system the Project area has a warm climate with soft winters and without clear dry season. It is located in the rainiest warm area of Guatemala. Climate is warm and wet, with maximum and minimum temperatures ranging between 36ºC and 14ºC. The average annual temperature is 25 ºC, the annual average relative air humidity is around 83% and the mean annual evapotranspiration of about 1668 mm.

In the view of the data submitted by the INSIVUMEH meteorological station in Puerto Barrios, rainfall is distributed through 200 and 220 days a year from May to January, with a dry season from March to May. Annual precipitation ranges from 1,800 to 4,000 mm.[6]

[4] For the first moritoring, 2016´s plantations were all included in a unique stratum. This stratum will not be monitored following the "Non-decrease" approach described in section 6.4. of the AR CD Methologolical tool: Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities. Version 04.2. Carbon stock in this stratum is expected to be low due to the short age of the planted trees.

[5] http://www.conap.gob.gt/index.php/sigap/planes-maestros.html?download=322:plan-maestro-reserva-protectora-de-manantiales-cerro-san-gil.pdf

[6] http://www.insivumeh.gob.gt/hidrologia/ATLAS_HIDROMETEOROLOGICO/Atlas_Hidrologico/isoyetas.jpg

Hydrology

Fresh water is the most valuable environmental service that the project area provides the population of the Department of Izabal. There are a variety of rivers that supply water to the cities of Puerto Barrios and Santo Tomas de Castilla, as well as 40 communities located within the Cerro San Gil reserve.

Hydrography of Cerro San Gil consists of nine sub-basins, 43 micro basins and 19 first order tributaries. These tributaries make a total of 187.94 km. linear streams. Water is used for domestic consumption and for irrigation of fields and farmland in most of communities.

Table 5. Main basins and sub-basins in project area

BASIN	SUB BASIN	SLOPE
Motagua River	San Francisco River	Caribe
	Bay of Amatique	Caribe
	Bay of Santo Tomas	Caribe
	Tenedores River	Caribe
Izabal Lake-Dulce River	Catchment of Izabal Lake-Dulce River	Caribe
	Tamejá River	Caribe
	Juan Vicente River	Caribe
	San Marcos River	Caribe

Physiography and soils[7]

Cerro San Gil area is located between the physiographic regions of Izabal Depression and Sedimentary High Lands (Tierras Altas). The first extends from the Izabal Lake and Dulce River to the Bay of Amatique; this region consists of a depression characterized by a rift valley whose origin is common to Motagua river´s. The Tierras Altas region extends from the border with Mexico to the Mico Mountains in the east of the country, and it is the largest represented in the area. Topography is very steep, with steep slopes forming rivers and streams in highly erodible lands.

The main soils of the project area belong to the Chacalté Series (Cha), which are shallow, well-drained soils that have been developed on hard and massive limestone in a warm and humid climate. Soil texture ranges from clay and clay loam to loamy. This type of soil is susceptible to erosion, mainly due water. Depth varies from a few centimeters to almost a meter. In some parts of the Rio San Gil area, such as in Las Escobas basin, rock exposures are numerous, as much as 50% or more of the surface.

In other areas the soils are shallow, coffee colour without subsoil well defined. On the surface of these soils orange and reddish clays or black coloured limestones are frequently found, as well as a thin layer of organic matter. In the northern part of the reserve, close to Lámpara and

[7] Soil information has been obtained from the document “PLAN MAESTRO 2008-2012. RESERVA PROTECTORA DE MANANTIALES CERRO SAN GIL”

Tamejá communities, soils are dark and with well-defined ground. Soil pH varies from moderately acid to neutral (6.5 to 7.0) with extremely low fertility.

The soils of the area belong to the alfisols and oxisols orders. Oxisols are common in the middle and lower parts of the basins, where land are used for subsistence farming and grazing, and alfisols are found mainly in forest areas. The soils are generally unsuitable for agricultural crops due to its low organic content and high sloping terrain, so it is considered that they have strictly forest vocation.

Vegetation

The floristic richness of Cerro San Gil is represented by 510 species. At relatively low levels of Cerro San Gil forest (900 m) it can be observed an association of cloud forest where specimens of mountain cypress or cypress (*Podocarpus guatemalensis*) grow.

It has two canopies, understory and a layer of herbaceous plants. The first canopy is constituted by trees between 50 and 60 m. height, while the second canopy trees range between 25 and 40 m.

In the first canopy are common specimens of taxonomic families such as *Sapotaceae, Moraceae, Meliaceae, Rutaceae, Guttiferaceae, Burseraceae, Fabaceae, Tiliaceae, Verbenaceae, Mimosacea* and *Myristicacea*. In the second canopy, representative families include: *Annonaceae, Rubiaceae, Sapotaceae, Ulmaceae, Fabaceae, Lauraceae, Capparidaceae and Flacourtaciae*.

The low forest of Cerro San Gil is characterized by containing a greater number of species of lianas, mostly represented by families *Araceae, Ceasalpinaceae, Malpighiaceae, Clusiaceae, Combretaceae* and *Poligonoceae*.

In addition, there are associations of plants growing on the banks of rivers and other bodies of lentic water; as well as plant associations which make up the flooded forests and mangroves. These are represented by communities of red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia sp*), San Juan (*Vochysia hondurensis*), confra (*Manicaria saccifera*), palo sangre (*Pterocarpus officinalis*), zapoton (*Pachira acuatica*) and bario (*Symphonia globulifera*).

Agricultural lands in the project area are croplands (mainly corn and beans) and grasslands (cattle ranching). Home gardens, which consist of medicinal plants and food use, are frequent in the project area. Plants grown in home gardens include corn (*Zea mays*), beans (*Phaseolus vulgaris*), coconut (*Cocus nucifera*), banana (Musa sapientum), mangoes (*Manguifera indica*), yucca (*Manihot sculenta*), malanga (*Colocassia sculenta*), ñame (*Dioscorea alatta*), chico (*Manilkara sapota*), caimito (*Cryssobalanus caimito*), sapodilla (*Pouteria zapota*), jocotes (*Spondias sp*.), citrus (*Citrus spp*.), cocoa (*Theobroma cacao*) and papaya (*Carica papaya*), among others.

Fauna

Ecosystems of the Cerro San Gil make project area rich in faunal biodiversity. Reptiles are represented by 4 families of snakes (38 species), 5 families of lizards (23 species) and 2 families

of turtles (3 species). Some of the species that have been observed in the project area include: green iguana (*Iguana iguana*), mazacuata (*Boa constrictor*), rustyhead snake (*Amastridium veliferum*), blunt-headed Tree Snake (*Imantodes cenchoa*), bejuquillo café (*Oxybelis aeneus*), bejuquillo verde (*Oxybelis fulgidus*), false coral (*Oxyrhopus petola*), bird snake (*Pseustes poecilonotus*), hojarasquera (*Rhadinaea decorata*), and Maya coral (*Micrurus hippocrepis*).

The mammals in Cerro San Gil include 14 species of rodents and 12 species of carnivorous mammals. The rest, is formed by orders of Marsupials, Xenarthra, Artiodactyla, Primates, Insectivores and Perissodactyls mammals. The most relevant species are cougar (*Puma concolor),* jaguar *(Panthera onca),* ocelot *(Leopardus pardalis),* northern tamandua *(Tamandua mexicana),* Baird's tapir *(Tapirus bairdii),* mantled howler *(Alouatta palliate)* and white-tailed deer (*Odocoileus virginianus*)*.*

Project area habitats keep 407 bird species belonging to 62 families and 18 taxonomic orders. 24 species are considered regional endemic and 58 species or sub-species are considered endemic to Mesoamerica. Among the variety of birdlife of Cerro San Gil, the following can be mention: mancolola (*Tinamus major*), toucan (*Ramphastus sulfuratus*), oropéndola (*Psaracalius wagleri*), aguilucho negriblanco (*Spizaetus melanoleucus*), aguilucho penachudo (*Spizaetus ornatos*), vireo manglero (*Vireo leucophvys*), and king vulture (*Sorcoramphus papa*)

With regards to invertebrates, 179 species of beetles and butterflies are reported in the project area.

Presence of rare and endangered species and their habitats

There is a high degree of endemism in the project area, mainly in the lowlands of the river basins Las Escobas and Tamejá. 15 species of endemic plants have been reported in Cerro San Gil, including:

- cordobancillo (*Rondeletia izabalensis*) Standl and Steyerm 1940, endemic of the Las Escobas River;
- cordobancillo (*R. lingüiformes*) Hemsl and Diag 1879, endemic of the mountains of Mico, is between 40 and 600 meters above sea level;
- cordobancillo (*R. macrocalix*) Standl and Steyerm 1947, endemic of Cerro San Gil;
- coralillo (*Cytharaxylum guatemalense*) Maldenke and D. Gibson, endemic of the Tamejá River, 50 meters above sea level;
- several species of palms like *Chamaedorea castillo-Montii*, *C. falcifera*, *C nationsiana*, and *C. stenocarpa*.

With regards to the fauna, it is worth pointing out two endemic species of salamander of the Las Escobas River basin: *Oedipina elongata* y *Oedipina sp*. Equally notable is the presence of endemic frogs in the same basin: *Eleutherodactylus sp.* (Leptodactylidae) y *Ptychohyla panchoi* (Hylidae).

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The ARR project is in compliance with all the applicable national and regional legal framework of the Government of Guatemala. The development of the project is based on the guidelines included in the current environmental regulations and laws in the country. This legal framework defines actions to prevent, minimize and mitigate potential impacts to the environment generated by a project, work, industry or any other activity.

All relevant information regarding to the compliance of the Project with laws, statutes, and other regulatory frameworks can be found in the supporting document, titled "Estudio de Viabilidad Legal, Ecológica, y socioeconómica del Proyecto Agroforestería y restauración del bosque para la conectividad Ecológica, Reducción de la Pobreza y Conservación de la Diversidad Biológica en Cerro San Gil, Caribe de Guatemala".

The project takes in account the environmental impacts national regulation "*Reglamento de Evaluación, Control y Seguimiento Ambiental*". According to this regulation, the administrative procedures applicable to projects, works, industries or new activities, begin with the presentation of the Initial Environmental Evaluation by the proposer to the General Direction of Environmental Management and Natural Resources, Ministry of Environment and Natural Resources (see further details in section 5).

The main national legal regulations, as the Constitution of the Republic of Guatemala "*Constitución de la República*" (Articles 64, 97.126); Protected areas Law "*Ley de Áreas Protegidas, Decreto 4-89*" (Articles, 5, 18, 20, 30, 33, 69), Forestry Law "*Ley Forestal, Decreto 101-96*" (Articles, 6, 8, 46, 98); Mitigation and Adaptation to Climate Change Law "*Ley Marco para la reducción a la vulnerabilidad, Adaptación obligatoria ante el Cambio Climático y la Mitigación de Gases de Efecto Invernadero, Decreto 7-201"* (Articles, 15, 20); contain texts which position the project positively, especially its benefits to environment, socioeconomy and governance.

Regarding the legal framework of the protected area, the Law for the creation of the protected area "*Ley de Creación del Área Protegida Cerro San Gil, Decreto 129-96*" discourages changes in land use, with the exception of reforestation. On the other hand, the project meets the Master Plan of the protected reserve "*Plan Maestro de la Reserva Protectora de Manantiales Cerro San Gil*". This master plan aims to promote the improvement and diversification of production and marketing agriculture (e.g. black pepper, xate, cardamom, citrus, …) and the development of alternative economic activities in critical areas and from traditional knowledge of natural resources.

Regarding the basis of international character, the Congress of Guatemala by Decree number 5-95 ratified the Convention on Biological Diversity - CBD. This agreement approved by 191 countries is constituted as the most important management tool of biological diversity at the global level. The objectives of this Convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits deriving from the use of resources genetic, by suitably access to genetic resources, by an appropriate transfer of technologies and by a proper funding.

1.12 Ownership and Other Programs

1.12.1 Project ownership

Landownership: all project plantations have been done in private lands. In the first instance there are two ways to demonstrate the ownership of the planted parcels: Land registry document and Municipal certify (these documents are available for the VVB on request).

Project ownership (in respect of a GHG emission reduction or removal): all land owners have signed a contract with Fundaeco for the technical and financial cooperation for the implementation of the project. Farmers have agreed that the plantation is carried out for their own benefit and that they have the exclusive possession and use of all the natural resources produced by the Project, including wood, fruits, rubber or other valorised outcomes, with the only exception being the carbon credits generated by Project. The farmers have agreed that the property rights on the carbon credits generated by this project are exclusively allocated to Fundaeco. Under this agreement, the beneficiary community is committed not to assert any property rights over the carbon credits generated and/or to be generated by the Project. On the other hand, there is a contract between Fundaeco and Livelihoods in which the property rights on the carbon credits generated by this project are allocated to Livelihoods (all mentioned contracts area available for the VVB on request).

1.12.2 Emissions Trading Programs and Other Binding Limits

GHG removals generated by the project will not be used for compliance with binding limits to GHG emissions since such limits are not enforced in Guatemala. There are no emissions trading program in place in the country.

1.12.3 Other Forms of Environmental Credit

The project neither has nor intends to generate any other form of GHG-related environmental credit.

1.12.4 Participation under Other GHG Programs

The project neither has nor intends to participate under other GHG programs.

1.12.5 Projects Rejected by Other GHG Programs

The project has not applied to receive credits from other GHG program and has not been rejected by any other GHG program.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

As this project is a grouped project, any instance implemented after validation must comply with section 3.4.9 of the VCS Standard version 3.4. Therefore any instance shall meet the following eligibility criteria:

1. Meet the applicability conditions set out in the CDM A/R Methodology: AR-ACM0003 "Afforestation and reforestation of lands except wetlands, version 02.0."

2. Use and apply technologies or measures similar to the specified in this project description for the first instance and apply them in the same manner. New instances will consist of ARR activities through planting and/or assisting natural regeneration;

3. Be subject to the baseline scenario determined in "Section 2.4 Baseline Scenario" of this Project Description for the specified project activity and geographic area, and therefore be established on lands where baseline scenario is continuing pre-project agricultural activities;

4. Have characteristics with respect to additionality that are consistent with that of the first instance, as described in the document entitled "Section 2.5 Additionality", facing similar barriers (Investment barriers, other than economic/financial barriers; Technological barriers; Barriers due to social conditions and/or Barriers due to prevailing practice);

5. Have the project boundary consistent with the physical/geographical boundary of the grouped project;

6. Have detailed geographic delineation of the boundary, in order to avoid double counting of emission reductions; and

7. Have documentary evidence of the starting date.

As indicated in section 3.4.10. "Inclusion of New Project Activity Instances", new project activity instances to be included in the grouped project shall:

1. Occur within the designated geographic area specified in section 1.9. of this document.

2. Comply with the set of abovementioned eligibility criteria.

3. Be included in the monitoring report with sufficient technical, financial, geographic and other relevant information to demonstrate compliance with the set of eligibility criteria and enable sampling by the validation/verification body.

4. Be validated at the time of verification against the set of eligibility criteria.

5. Have evidence of project ownership, in respect of each project activity instance, held by the project proponent from the respective start date of each project activity instance.

6. Be eligible for crediting from the start date of the instance through to the end of the project crediting period (only).

Leakage Management

The applied methodology considers only one source of leakage: increase in GHG emissions attributable to displacement of pre-project agricultural activities. Leakages are not expected in this grouped project and in the first project activity instance.

Nevertheless, if displacement of agricultural activities occurs then potential leakage will be minimized by avoiding the decrease in carbon stocks outside the project boundary (e.g. looking for unused agricultural lands outside the project boundary, training local people on more efficient agricultural techniques, etc.). They main measures to be implemented if there is a displacement of pre-project agricultural activities are:

- Provide technical advising to farmers when looking for alternative places to develop the agricultural activity (looking for places with low biomass carbon stocks).

- Provide technical advising to farmers to change the productive activity (different type of crops, agroforestry systems, etc.).

- Improving the accuracy of the information of the displaced activities (area displaced, location of displacement, etc.)

When leakage occurs then they will be calculated using the A/R CDM Methodological tool: Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity. Version 0.2.0.

Commercially Sensitive Information

At this time there is no commercially sensitive information within this Project Description that will be excluded from the public Project Description.

Further Information

Not applicable.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

The methodology to be applied in this VCS ARR project is the CDM afforestation and reforestation Large-scale Consolidated Methodology: **AR-ACM0003 "Afforestation and reforestation of lands except wetlands, version 02.0."**

The following methodological tools, to which the selected methodology refers to, are used:

a) Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities. Version 01;

b) Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity. Version 04.0.0;

c) Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities. Version 03.1;

d) Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities. Version 01.1.0;

e) Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities. Version 0.4.2;

f) Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity. Version 0.2.0.

Other A/R CDM tools used in this project are:

a) Demonstrating appropriateness of volume equations for estimation of aboveground tree biomass in A/R CDM project activities. Version 1.0.1;

b) Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities. Version 01.0.0;

c) Calculation of the number of sample plots for measurements within A/R CDM project activities. Version 2.1.0.

2.2 Applicability of Methodology

Applicability Conditions of AR-ACM0003

This methodology is applicable under the following conditions:

a) The land subject to the project activity does not fall in wetland category;

b) Soil disturbance attributable to the project activity does not cover more than 10 per cent of area in each of the following types of land, when these lands are included within the project boundary:

i. Land containing organic soils;

ii. Land which, in the baseline, is subjected to land-use and management practices and receives inputs listed in appendices 1 and 2 to this methodology.

In relation to the applicability conditions listed above, in this proposed project activity:

a) The land subject to the project activity is not wetlands. Project lands are not inundated or saturated by water for all or part of the year, at such frequency and duration that under natural conditions they support organisms adapted to poorly aerated and/or saturated soil. Project lands are classified, based on the pre-project land use, as grasslands and croplands.

b) The only soil disturbance expected is pit digging for soil preparation. Considering planed planting densities and pit sizes, soil disturbances attributable to the project activity cover less than 10% of project area.

Applicability Conditions of the used tools

Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities.

a) *Forestation of the land*[8] *within the proposed project boundary performed with or without being registered as the A/R CDM project activity shall not lead to violation of any applicable law even if the law is not enforced.* The project is in compliance with applicable legal and regulatory requirements (see section 1.11)

b) *This tool is not applicable to small - scale afforestation and reforestation project activities.* This project is a large scale project based on CDM rules (see section 1.7.)

Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity.

a) *The tool is applicable to all occurrence of fire within the project boundary.* If fire occurs in the project scenario the tool will be applicable.

b) *Non-CO2 GHG emissions resulting from any occurrence of fire within the project boundary shall be accounted for each incidence of fire which affects an area greater than the minimum threshold area reported by the host Party for the purpose of defining forest, provided that the accumulated area affected by such fires in a given year is ≥5% of the project area.* The tool

[8] In the context of this tool, forestation is used for the identification of possible land use scenarios that go beyond afforestation and reforestation as defined in the Marrakech Accords and includes the any establishment of forest through natural or artificial means.

will be applied for each incident of fire which affects an area greater than 0.5 ha, been the accumulated area of fires in a year higher than ≥5% of the project area.

Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities

This tool has no internal applicability conditions.

Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities

This tool has no internal applicability conditions.

Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities

This tool is applicable when the areas of land, the baseline scenario, and the project activity meet the following conditions:

a) The areas of land to which this tool is applied:

i. Do not fall into wetland category; or

ii. Do not contain organic soils as defined in "Annex A: glossary" of the IPCC GPG LULUCF 2003;

iii. Are not subject to any of the land management practices and application of inputs as listed in the Tables 1 and 2;

Project lands are degraded croplands and grasslands not containing organic soils. In the case of croplands they are mainly short-term or set aside croplands without tillage and with low inputs. In the case of grasslands they are degraded lands with low inputs.

b) The A/R CDM project activity meets the following conditions:

i. Litter remains on site and is not removed in the A/R CDM project activity; and

ii. Soil disturbance attributable to the A/R CDM project activity, if any, is:

- *In accordance with appropriate soil conservation practices, e.g. follows the land contours;*
- *Limited to soil disturbance for site preparation before planting and such disturbance is not repeated in less than twenty years.*

In this project case litter is not removed and soil disturbances are limited to those due to site preparation (pit digging).

Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity

This tool is not applicable if the displacement of agricultural activities is expected to cause, directly or indirectly, any drainage of wetlands or peat lands. Project lands are not wetlands or peatlands.

Demonstrating appropriateness of volume equations for estimation of aboveground tree biomass in A/R CDM project activities

This tool has no internal applicability conditions.

Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities

This tool has no internal applicability conditions

Calculation of the number of sample plots for measurements within A/R CDM project activities

This tool has no internal applicability conditions

2.3 Project Boundary

DETAILED GEOGRAPHIC DELINEATION OF THE BOUNDARY

The project boundary is described in section 1.9. including the geographical identification of each discrete area of land.

RELEVANT GHG SOURCES, SINKS AND RESERVOIRS

Project GHG emission sources

In the applied methodology the only source of project emission is biomass burning. In the project this will be a source of emission, in some planted parcels, during site preparation and in forest fires.

Table 6. Project emissions sources

Source		Gas	Included?	Justification/Explanation
Project	Burning of woody biomass	CO_2	No	CO_2 emissions due to burning of biomass are accounted as a change in carbon stock.
		CH_4	Yes	Burning of woody biomass for the purpose of site preparation, or as part of forest management, is allowed under this methodology.
		N_2O	Yes	Burning of woody biomass for the purpose of site preparation, or as part of forest management, is allowed under this methodology.

Baseline and project GHG removals by sinks

Table 7. Baseline and project carbon pools

Carbon pool		Included?	Justification/explanation
Baseline	Above ground biomass	Yes	Major carbon pool subject to the project activity.
	Below ground biomass	Yes	Carbon stock in this pool is expected to increase due to the implementation of the ARR VCS project activity.
	Dead wood	Yes	Even stock changes in Dead wood in the baseline are not expected, this carbon pool has been considered because project activity is expected to lead to an increase of Dead wood stock changes.
	Litter	Yes	Even stock changes in Litter in the baseline are not expected, this carbon pool has been considered because project activity is expected to lead to an increase of Litter stock changes.
	Soil organic carbon	Yes	Even stock changes in SOC in the baseline are not expected, this carbon pool has been considered because project activity is expected to lead to an increase of SOC stock changes.
Project	Above ground	Yes	Major carbon pool subject to the project activity.
	Below ground	Yes	Carbon stock in this pool is expected to increase due to the implementation of the ARR VCS project activity.
	Dead wood	Yes	Carbon stock in this pools may increase due to implementation of the ARR VCS project activity
	Litter	Yes	Carbon stock in this pools may increase due to implementation of the ARR VCS project activity

	Soil organic carbon	Yes	Carbon stock in this pools may increase due to implementation of the ARR VCS project activity

Sources of leakage

Table 8. Leakage emissions sources

Sources	Gas	Included?	Justification/Explanation
Displacement of agricultural activities	CO_2	Yes	Main gas of this source due to the change in carbon stocks of AGB, BGB, DW, L and SOC pools. This source of leakage is not expected in the grouped project and does not occur in the first instance.
	CH_4	No	Potential emission is negligible.
	N_2O	No	Potential emission is negligible.

2.4 Baseline Scenario

The baseline scenario is justified using the "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities, version 01", as is required in the selected methodology (AR-ACM0003 v02.2).

Step 0: Preliminary screening based on the starting date of the ARR project activity

- The starting date of the project is 26/08/2013; therefore it was after 31 December 1999.
- The incentive from the planned use of "carbon credits" was seriously considered in the decision to proceed with the project. There are evidences of this statement in the contract between FUNDAECO and LIVELIHOODS for the implementation of the project (Framework cooperation agreement) and in signed annual conventions (Specific convention on Module 1 "Tree planting program").

Step 1: Identification of alternative land use scenarios to the proposed A/R CDM project activity

Sub-step 1a: Identify credible alternative land use scenarios to the proposed CDM project activity

The alternative scenarios applicable to the CPA context are:

1. Status Quo: Continuation of the pre-project land use. Status Quo is land remaining with agricultural activities (Croplands and Grasslands).
2. Afforestation/reforestation of the land within the boundaries of the project activities performed without being registered as the ARR VCS project activity.

Sub-step 1b: Consistency of credible land use scenarios with enforced mandatory applicable laws and regulations

As it is mentioned in chapter 1.11. of this document, the project is in compliance with all relevant local, state and national, applicable legal and regulatory requirements as analyzed in chapter 4 of the document “Estudio de Viabilidad Legal, Ecológica, y socioeconómica del Proyecto Agroforestería y restauración del bosque para la conectividad Ecológica, Reducción de la Pobreza y Conservación de la Diversidad Biológica en Cerro San Gil, Caribe de Guatemala.” and in chapter VI of the document “Diagnóstico ambiental”.

The land use prior to the project implementation (Cropland and Grassland) is also in compliance with legal and regulatory requirements as indicated in the management plant of the protected reserve where the project is been implemented (Plan Maestro de la Reserva Protectora de Manantiales Cerro San Gil).

Step 2: Barrier analysis

Sub-step 2a: Identification of barriers that would prevent the implementation of at least one alternative land use scenarios

a) Investment barriers, other than economic/financial barriers

This project is implemented on degraded grasslands and croplands with three main objectives: ecological connectivity, poverty reduction and biodiversity conservation. The project activity will be implemented through three financial sources: VCS project proponent (Livelihoods), National forest subsidies and Ministry of Agriculture (MAGA).

The national forest subsidy co-financing the project is PINFOR (Programa de Incentivos Forestales/Forest incentive program) created under the Forest Law of 1996, in order to promote the reforestation, the creation of forests and Sustainable Forest Management. It was scheduled to run during 20 years and its prolongation beyond 2016 for an extra 30 years. INAB is the state body that was created to administrate PINFOR (and PINPEP, a similar subsidy for special land tenure cases). PINFOR´s mission is "to promote the creation of regional forestry production groups of high productivity to enable the supply of forestry competitive products, to reduce deforestation and to generate environmental services as well as employment in the rural area" The incentives are a cash payment that the government grants to the owner of forests, in order to enforce reforestation projects or the managing of natural forests. The incentive is granted once the management plan is approved by INAB. For a given land owner, application to PIFOR subsidy should be done through an official form before plantation operations. This includes a land suitability analysis and a commitment to observe a sustainable management plan of the reforested area. INAB approves the application in the same civil year. Then, the land owner has one year to execute reforestation plans. Once reforestation complete, INAB evaluates project execution by a field visit and triggers initiation of yearly payments to the landowner.

On the other hand, the Ministry of Agriculture will provide technical and financial support to FUNDAECO for the implementation of the project.

Therefore, alternative baseline scenario 2 (Afforestation/reforestation of the land within the boundaries of the project activities performed without being registered as the ARR VCS project activity) will have at least one source of financing (PINFOR and/or PINPEP) but will face cashflow problems. This type of ARR projects need important initial investments not solved by National subsidies.

The ARR project is possible thanks to the initial investment of Livelihoods that is possible because of the VCS benefits that project provides to this fund. The approach of the forest carbon project is the partnership between the investor, interested in improving rural communities' livelihoods and in getting carbon offsets under the VCS, a local NGO providing with experience working in the project area with local people in environmental activities (FUNDAECO), and local land owners. The local NGO has demonstrated technical capacity in environment conservation, forestry, rural development, mobilizing local people, etc. but needs funding to finance such activities. Local communities and farmers do not have the capacity for implementing the project without the support of FUNDAECO. The partnership between these three actors (Livelihoods, Fundaeco and local land owners) is a key factor for the ARR project to overcome investments barriers.

Project activities will cover the financing and support needed during the entire project period, guaranteeing the appropriate implementation and long-term management of the restored areas.

b) Technological barriers

An ARR project of this scale in the protected area "Reserva protectora de manantiales Cerro San Gil" will face several technological barriers: need of technical knowledge of large scale ARR activities; need of knowledge of the project area; need of experience working with local people; need of technical knowledge to fulfil PINFOR requirements; and need of logistics capability to manage this type of projects (large scale, high number of landowners, access problems, several local languages, etc.).

This ARR project, implemented by FUNDAECO, will overcome all these barriers because the NGO has proven experience working in the project area, with the local people and on activities similar to project activity. FUNDAECO participates as executive secretariat in the management of the protected area since 1997. Without the infrastructure, logistic, awareness expertise and experience on working with local people, provided by Fundaeco (which depends on funds from VCS credits), local landowners would not be able to develop an ARR project on a significant scale.

Sub-step 2b. Elimination of land use scenarios that are prevented by the identified barriers

There are two possible future baseline scenarios:

1. Status Quo: Continuation of the land as a degraded croplands and grasslands

2. Implementation of the project activity not undertaken as a VCS project activity;

Scenario 1 does not face any of the barriers described above, and can be assumed to be the baseline scenario.

Scenario 2 faces all the aforementioned barriers, and would not be implemented unless otherwise it is undertaken as VCS project.

The actual net GHG removals by sinks will be increased above those that would have occurred in the absence of the project, because Scenario 1 is the most plausible scenario and it is different from the project activity.

Sub-step 2c. Determination of baseline scenario

In applying the decision tree to the outcome of sub-steps 2a and b, the following baseline scenario has been identified: Status Quo: Continuation of the land as a degraded croplands and grasslands.

Decision tree: Is forestation without being registered as an A/R CDM project activity included in the list of land use scenarios that are not prevented by any barrier? No. Does the list contain only one land use scenario? Yes, then the remaining land use is the baseline scenario

Step 4: Common practice analysis

There are not ARR activities similar to this VCS project implemented or been implemented in the region. Its specific characteristics make this project the first of its kind:

- Project scale and planted parcels size: this project has been designed as a grouped project with an expected project are higher than 4,000 ha, and the mean planted parcel area is between 2 and 4 ha.

- Number of landowner: the ownership of the project area distributed in several land owner and not concentrated

- Plantation systems: four main plantation systems are been implemented. Three of the plantation systems consider mixed species and two of the include agroforestry systems.

- Project area: the project is implemented in the protected area “Reserva protectora de manantiales Cerro San Gil”

The combination of these characteristics makes this project unique in the region and in the country.

As explained in step 2, ARR project activities, in scales similar to the project, face two main barriers (Investment barriers, other than economic/financial barriers and Technological barriers and Barriers due to social conditions). To develop an activity with the specific characteristics of this project it is necessary to be able to overcome all those barriers. ARR projects with different characteristics (i.e. smaller scale) do not face the mentioned barriers (not specific technological knowledge and not important funding are needed).

Base on the abovementioned, the project activity is not the common practice and therefore is not the baseline.

With step 4 being met, the proposed ARR VCS project activity is not the baseline scenario, and is therefore additional.

2.5 Additionality

Demonstration and assessment of additionality has been done in section 2.4. using the "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities" version 01, as it is required in the selected methodology.

2.6 Methodology Deviations

The project and project monitoring plan meet all of the requirements of the applied methodology and does not deviate from the baseline scenario, additionality determination, or inclusion of project GHG sources, sinks and reservoirs.

3 ESTIMATED GHG EMISSION REDUCTIONS AND REMOVALS

3.1 Baseline Emissions

The baseline net GHG removals by sinks are estimated using the equation 1 in section 5.4 of the methodology AR ACM0003 (Version 02.0):

$$\Delta C_{BSL,t} = \Delta C_{TREE_BSL,t} + \Delta C_{SHRUB_BSL,,t}\ \Delta C_{DW_BSL,t} + \Delta C_{LI_BSL,t}$$

Where:

$\Delta C_{BSL,t}$	= Baseline net GHG removals by sinks in year *t*; t CO_2-e
$\Delta C_{TREE_BSL,t}$	= Change in carbon stock in baseline tree biomass within the project boundary in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{SHRUB_BSL,,t}$	= Change in carbon stock in baseline shrub biomass within the project boundary, in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{DW_BSL,t}$	= Change in carbon stock in baseline dead wood biomass within the project boundary, in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"; t CO_2-e
$\Delta C_{LI_BSL,t}$	= Change in carbon stock in baseline litter biomass within the project boundary, in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"; t CO2-e

As confirmed in section 2.4 of this document the most likely baseline scenario is considered to be the land-use prior to the implementation of the project activity (degraded agricultural lands). Based on the information collected from local famers participating in the project two baseline strata have been identified: croplands and grasslands. In the first case two sub-strata can be described based on the land management: long term cultivation and cultivation with fallow periods "guamil".

Changes in the carbon stocks in the living biomass – ($\Delta C_{TREE_BSL,t}$ + $\Delta C_{SHRUB_BSL,t}$)

Changes in the carbon stocks in the living biomass pool of tree and non-tree vegetation are expected to be zero in the absence of project activity.

In both strata biomass stocks in the project area is different than zero, because the presence of scattered trees, but the carbon stock change will not be significant, because of the management practices and the ecological conditions. It is expected that the existing biomass stock will remain, in the long, in a steady state

In the specific case of "guamil" baseline stratum, during the fallow stage, the carbon stocks and change in carbon stocks may be significant. Nevertheless, in the long term the carbon stocks in this stratum will be in a steady state. All trees in the "guamil" stratum are harvested at the beginning of the cropping period, therefore the long term average carbon stock will be constant.

In line with the abovementioned and following the A/R Methodological Tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities (Version 04.2.), ex-ante and ex-post change in carbon stock in trees and shrubs in the baseline may be accounted as zero (for the three considered baseline strata).

This statement is demonstrated based on the following conditions:

Guamil stratum

a) *Land is subjected to periodic cycles (e.g. slash-and-burn, or clearing-regrowing cycles) so that the biomass oscillates between a minimum and a maximum value in the baseline.*

This is the case of the Guamil system with crop rotation and fallow periods.

Rest cropland and grassland baseline strata

a) *The pre-project trees are neither harvested, nor cleared, nor removed throughout the crediting period of the project activity*.

This is the project case because thinning and harvesting are not planned in the project activity;

b) The pre-project trees do not suffer mortality because of competition from trees planted in the project, or damage because of implementation of the project activity, at any time during the crediting period of the project activity.

Pre-existing trees are bigger that planted trees and it is not expected a faster growth of planted trees compared to pre-existing trees so it is supposed a light competition. Project activities will not lead to damages of pre-existing trees. Furthermore, site preparation and planting activities are done manually. Therefore, mortality of pre-existing trees it is not expected because of project activity;

c) The pre-project trees are not inventoried along with the project trees in monitoring of carbon stocks but their continued existence, consistent with the baseline scenario, is monitored throughout the crediting period of the project activity

The continued existence of the pre-existing trees will be monitored.

Changes in the carbon stocks in baseline dead wood - $\Delta C_{DW_BSL,t}$

Baseline scenario is a degraded cropland or grassland with scattered trees and dead wood. A decrease of this carbon pool is expected because of the degradation of the existing dead wood.

Therefore, ex-ante and ex-post changes in carbon stocks in baseline dead wood biomass are estimated as zero.

This can be also justified based on the conservative approach described in section 6.2 of AR-TOOL12."Conservative default-factor debased method for estimation of carbon stock in dead wood". As changes in the carbon stocks in the living biomass are accounted as zero, then changes in carbon stocks in baseline dead wood biomass can be estimated as zero.

Changes in the carbon stocks in baseline litter - $\Delta C_{LI_BSL,t}$

With the same approach considered for dead wood, ex-ante and ex-post changes in carbon stocks in baseline litter are estimated as zero.

This can be also justified based on the conservative approach described in section 7.2 of AR-TOOL12. As changes in the carbon stocks in the living biomass are accounted as zero, then changes in carbon stocks in baseline litter can be estimated as zero.

3.2 Project Emissions

The actual net GHG removals by sinks are estimated using the equations in section 5 of the methodology AR ACM0003 (Version 02.0). The actual net GHG removals by sinks are calculated using equation 2 of the methodology.

$$\Delta C_{ACTUAL,t} = \Delta C_{P,t} - GHG_{E,t}$$

Where:

$\Delta C_{ACTUAL,t}$	= Annual actual net greenhouse gas removals by sinks at time *t*; t CO_2-e yr^{-1}
$\Delta C_{P,t}$	= Change in carbon stocks in project, occurring in the selected carbon pools, at time *t*; t CO_2-e yr^{-1}
$GHG_{E,t}$	= Increase of non-CO_2 GHG emissions within the project boundary as a result of the implementation of the A/R CDM project activity, in year *t*, t CO_2-e

Change in the carbon stocks in project, occurring in the selected carbon pools in year *t* shall be calculated as follows:

$$\Delta C_{P,t} = \Delta C_{TREE_PROJ,t} + \Delta C_{SHRUB_PROJ,t} + \Delta C_{DW_PROJ,t} + \Delta C_{LI_PROJ,t} + \Delta SOC_{AL,t}$$

Where:

$\Delta C_{P,t}$	= Change in carbon stocks in project, occurring in the selected carbon pools, at time *t*; t CO_2-e yr^{-1}
$\Delta C_{TREE_PROJ,t}$	= Change in carbon stock in tree biomass in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{SHRUB_PROJ,t}$	= Change in carbon stock in shrub biomass in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{DW_PROJ,t}$	= Change in carbon stock in dead wood in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"; t CO2-e
$\Delta C_{LI_PROJ,t}$	= Change in carbon stock in litter in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"; t CO2-e
$\Delta SOC_{AL,t}$	= Change in carbon stock in SOC in project, in year *t*, in areas of land meeting the applicability conditions of the tool "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities", as estimated in the same tool; t CO2-e

Change in carbon stock in tree biomass - $\Delta C_{TREE_PROJ,t}$

$\Delta C_{TREE_PROJ,t}$, in this grouped project, may be calculated using sections 6, 7 and 8 of AR-TOOL14.

In the case of the first project activity instance, ex-post estimations of change in carbon stock in trees between two points of time will be done using the "Difference of two independent stock estimations" method (see section 6.1 of AR-TOOL14). This will be based on measurements of sample plots to estimate carbon stock in trees at a point of time (see section 8.1 of AR-TOOL14). For ex-ante estimations the "Estimation by modelling of tree growth and stand development" method will be used (see section 8.2 of AR-TOOL14).

a) Ex-post estimations

Change in carbon stock in trees in a year is estimated following equation 11 of AR-TOOL14 "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities".

$$\Delta C_{TREE,t} = \frac{C_{TREE,t2} - C_{TREE,t1}}{T} \times 1year$$

Where:

ΔC_{TREE}	= Change in carbon stock in trees within the project boundary in year *t*; t CO2e
$C_{TREE,t2}$	= Carbon stock in trees within the project boundary at time *t2*; t CO2e.
$C_{TREE,t1}$	= Carbon stock in trees within the project boundary at time *t1*; t CO2e
T	= Time elapsed between two successive estimations (T=*t*2 – *t*1); yr. Note: Value of *T* does not have to be a whole number

The method selected for the ex-ante estimation of $C_{TREE,t2}$ is "Estimation by measurement of sample plots" and "Stratified random sampling" in section 8.1.1. in AR-TOOL 14.

Next equations are used:

$$C_{TREE,t} = \frac{44}{12} \times CF_{TREE} \times B_{TREE,t}$$ (Equation 12 of AR-TOOL14)

$$B_{TREE,t} = A \times b_{TREE,t}$$ (Equation 13 of AR-TOOL14)

$$b_{TREE,t} = \sum_{i=1}^{m} w_i \times b_{TREE,t,i}$$ (Equation 14 of AR-TOOL14)

$$b_{TREE,t,i} = \frac{\sum_{p=1}^{ni} b_{TREE,t,p,i}}{n_i}$$ (Equation 16 of AR-TOOL14)

Where:

$C_{TREE,t}$	= Carbon stock in tree biomass within the project boundary at a point of time in year *t*; t CO*2*-e. Note: for the first verification, the variable $C_{TREE, t1}$ will be set equal to zero based on the results of section 3.1.
CF_{TREE}	= Carbon fraction of tree biomass; t C (t d.m.)$^{-1}$. A default value of 0.47 is used unless transparent and verifiable information can be provided to justify a different value.
$B_{TREE,t}$	= Tree biomass in the tree biomass estimation strata; t d.m.
$b_{TREE,t}$	= Mean tree biomass per hectare within the project boundary at a given point of time in year *t*; t d.m. ha^{-1}

A	= Sum of areas of the tree biomass estimation strata; ha
w_i	= Ratio of the area of stratum *i* to the sum of areas of tree biomass estimation strata (A_i/A), dimensionless
$b_{TREE,t,i}$	= Mean tree biomass per hectare in stratum *i* at a given point of time in year *t*; t d.m. ha^{-1}
$b_{TREE,t,p,i}$	= Tree biomass per hectare in sample plot *p* of stratum *i* at a given point of time in year *t*; t d.m. ha^{-1}
n_i	= Number of sample plots in stratum *i*

The plot biomass value is estimated in year t as follows:

$b_{TREEp,i} = \frac{B_{TREE,p,i}}{A_{PLOT,i}}$ (Equation 1 Appendix 1, AR-TOOL14)

$B_{TREEp,i} = \sum_j B_{TREEj,p,i}$ (Equation 2 Appendix 1, Ar-TOOL14)

$B_{TREEj,p,i} = \sum_l B_{TREEl,j,p,i}$ (Equation 3 Appendix 1, Ar-TOOL14)

Where:

$b_{TREEp,i}$	= Tree biomass per hectare in sample plot *p* of stratum *i* at a given point of time in year *t*; t d.m. ha^{-1}
$B_{TREEp,i}$	= Tree biomass in sample plot *p* of stratum *i* at a given point of time in year *t*; t d.m.
$A_{PLOT,i}$	= Size of sample plot in stratum i; ha
$B_{TREEj,p,i}$	= Biomass of trees of species *j* in sample plot *p* of stratum *i* at a given point of time in year *t*; t d.m.
$B_{TREEl,j,p,i}$	= Biomass of tree *l* of species *j* in sample plot *p* of stratum *i* at a given point of time in year *t*; t d.m.

Biomass of a tree in a sample plot is estimated by using equation 5 in Appendix 1 of AR-TOOL 14:

$B_{TREEl,j,p,i} = V_{TREE,j}(x_{1,l}, x_{2,l}, x_{3,l}, \ldots) \times D_j \times BEF_{2,j} \times (1 + R_j)$

Where:

$B_{TREEl,j,p,i}$	= Biomass of tree *l* of species *j* in sample plot *p* of stratum *i*; t d.m.
R_j	= Root-shoot ratio for tree species *j*; dimensionless. The value of R_j is estimated as (R_j=$e^{(-1.085+0.9256*\ln b)}$/b)) where *b* is the above-ground tree biomass per hectare (in t d.m. ha^{-1}), unless transparent and verifiable information can be provided to justify a

different value.

$V_{TREE,j}(x_{1,l}, x_{2,l}, x_{3,l}, \dots)$	= Stem volume of tree *l* of species *j* in sample plot *p* of stratum i, estimated from the tree dimension(s) as entry data into a volume table or volume equation; m^3
D_j	= Density (over-bark) of tree species *j*; t d.m. m^{-3} Values are taken from Table 3A.1.9 of IPCC GPG-LULUCF 2003 unless transparent and verifiable information can be provided to justify different values.
$BEF_{2,j}$	= Biomass expansion factor for conversion of tree stem biomass to above-ground tree biomass, for tree species *j*; dimensionless For ex-post estimation the conservative default value of 1.15 is used, unless transparent and verifiable information can be provided to justify a different value.

Above equations will be used for the first verification of the first project activity instance. Nevertheless, in future verifications of the first instance and in potential new instances, in the framework of this grouped project, other methods of AR-TOOL14 may be also used, as in example the following:

- Estimating change in carbon stock in trees between two points of time by:
  - direct estimation of change by re-measurement of sample plots (section 6.2 of AR-TOOL14)
  - demonstration of "no-decrease" (section 6.4 of AR-TOOL14)
- Estimating carbon stock in trees at a point of time by:
  - measurement of sample plots with a double sampling method (section 8.1.2. of AR-TOOL14)
  - updating previous stock by direct estimation of change (section 8.4. of AR-TOOL14)
- Methods of plot biomass measurement with variable area plots (Appendix 1.2. of AR-TOOL14)

b) Ex-ante estimations

Ex-ante estimations of change in carbon stock in trees (ΔC_{TREE}) have been done using above equations 12, 13 and 14 of AR-TOOL14, with the following specific conditions:

- $b_{TREE,\,t,i}$ is calculated following this equation:

$$b_{TREE,\,t,i} = AGB_{TREE,t,i} \times (1+R_j)$$

where $AGB_{TREE,t,i}$ is the tree above ground biomass in stratum *i* in year *t*; t d.m. ha^{-1}

- $AGB_{TREE,t,i}$ is calculated following this equation:

$$AGB_{TREE,t,i} = AGBMAI_{,i} \times PA$$

where $AGBMAI_{,i}$ is the tree above ground biomass mean annual increment in stratum *i*; t d.m. ha^{-1}, and *PA* us the plantation age, in years

- *The* $AGBMAI_{,i}$ used are included in the following table:

Table 9: AGB mean annual increment

Plantation system	$AGBMAI_{,i}$	Source
Rubber	14.15	PICA 2013 MONITORING REPORT[9]
Forest plantation	17	IPCC 2003 Table 3A.1.6[10]
Agroforestry systems	17	IPCC 2003 Table 3A.1.6
Orchards	3.12	Based on IPCC 2003 Table 3A.1.6[11]

[9] 2013 Monitoring Report of the VCS ARR Project: Promoting sustainable development through natural Rubber tree plantation in Guatemala.
[10] IPCC (Intergovernmental Panel on Climate Change). 2003. Good practice guidance for land use, land-use change and forestry. Intergovernmental Panel on Climate Change.
[11] This value has been obtained considering the AGBMAI in orchards is a 18% of Forest plantations based on the relation between the planting densities of both systems (17*204/1111).

Table 10. Mean tree biomass per hectare in the different project plantation systems

	Rubber				Forest plantations				AFS				Orchard			
Age (year)	**AGBMAI**	$AGB_{TREE,t}$	$AGB_{TREE,t} \times R_j$	$b_{TREE,t}$	**AGBMAI**	$AGB_{TREE,t}$	$AGB_{TREE,t} \times R_j$	$b_{TREE,t}$	**AGBMAI**	$AGB_{TREE,t}$	$AGB_{TREE,t} \times R_j$	$b_{TREE,t}$	**AGBMAI**	$AGB_{TREE,t}$	$AGB_{TREE,t} \times R_j$	$b_{TREE,t}$
1	14.15	14.15	3.93	18.08	17.00	17.00	4.65	21.65	17.00	17	4.65	21.65	3.12	3	0.97	4.09
2	14.15	28.30	7.46	35.76	17.00	34.00	8.84	42.84	17.00	34	8.84	42.84	3.12	6	1.84	8.08
3	14.15	42.45	10.85	53.30	17.00	51.00	12.86	63.86	17.00	51	12.86	63.86	3.12	9	2.68	12.04
4	14.15	56.60	14.16	70.76	17.00	68.00	16.79	84.79	17.00	68	16.79	84.79	3.12	12	3.50	15.98
5	14.15	70.75	17.41	88.16	17.00	85.00	20.64	105.64	17.00	85	20.64	105.64	3.12	16	4.30	19.91
6	14.15	84.90	20.62	105.52	17.00	102.00	24.43	126.43	17.00	102	24.43	126.43	3.12	19	5.09	23.82
7	14.15	99.05	23.78	122.83	17.00	119.00	28.18	147.18	17.00	119	28.18	147.18	3.12	22	5.87	27.72
8	14.15	113.20	26.90	140.10	17.00	136.00	31.89	167.89	17.00	136	31.89	167.89	3.12	25	6.64	31.61
9	14.15	127.35	30.00	157.35	17.00	153.00	35.56	188.56	17.00	153	35.56	188.56	3.12	28	7.41	35.50
10	14.15	141.50	33.08	174.58	17.00	170.00	39.20	209.20	17.00	170	39.20	209.20	3.12	31	8.17	39.38
11	14.15	155.65	36.13	191.78	17.00	187.00	42.82	229.82	17.00	187	42.82	229.82	3.12	34	8.92	43.26
12	14.15	169.80	39.16	208.96	17.00	204.00	46.41	250.41	17.00	204	46.41	250.41	3.12	37	9.67	47.12
13	14.15	183.95	42.17	226.12	17.00	221.00	49.98	270.98	17.00	221	49.98	270.98	3.12	41	10.41	50.99
14	14.15	198.10	45.16	243.26	17.00	238.00	53.52	291.52	17.00	238	53.52	291.52	3.12	44	11.15	54.85
15	14.15	212.25	48.14	260.39	17.00	255.00	57.05	312.05	17.00	255	57.05	312.05	3.12	47	11.88	58.71
16	14.15	226.40	51.11	277.51	17.00	272.00	60.57	332.57	17.00	272	60.57	332.57	3.12	50	12.62	62.56
17	14.15	240.55	54.05	294.60	17.00	289.00	64.06	353.06	17.00	289	64.06	353.06	3.12	53	13.34	66.41
18	14.15	254.70	56.99	311.69	17.00	306.00	67.54	373.54	17.00	306	67.54	373.54	3.12	56	14.07	70.26
19	14.15	268.85	59.92	328.77	17.00	323.00	71.01	394.01	17.00	323	71.01	394.01	3.12	59	14.79	74.10
20	14.15	283.00	62.83	345.83	17.00	0.00	0.0046	0.00.46	17.00	340	74.46	414.46	3.12	0.00	0.00	0.00
21	14.15	297.15	65.73	362.88	17.00	17.00	4.65	21.65	17.00	357	77.90	434.90	3.12	3	0.97	4.09
22	14.15	311.30	68.62	379.92	17.00	34.00	8.84	42.84	17.00	374	81.33	455.33	3.12	6	1.84	8.08
23	14.15	325.45	71.51	396.96	17.00	51.00	12.86	63.86	17.00	391	84.74	475.74	3.12	9	2.68	12.04
24	14.15	339.60	74.38	413.98	17.00	68.00	16.79	84.79	17.00	408	88.15	496.15	3.12	12	3.50	15.98
25	14.15	353.75	77.24	430.99	17.00	85.00	20.64	105.64	17.00	425	91.54	516.54	3.12	16	4.30	19.91
26	14.15	367.90	80.10	448.00	17.00	102.00	24.43	126.43	17.00	442	94.93	536.93	3.12	19	5.09	23.82
27	14.15	382.05	82.95	465.00	17.00	119.00	28.18	147.18	17.00	459	98.30	557.30	3.12	22	5.87	27.72
28	14.15	396.20	85.79	481.99	17.00	136.00	31.89	167.89	17.00	476	101.67	577.67	3.12	25	6.64	31.61
29	14.15	410.35	88.62	498.97	17.00	153.00	35.56	188.56	17.00	493	105.02	598.02	3.12	28	7.41	35.50
30	14.15	0.00	0.00	0.00	17.00	170.00	39.20	209.20	17.00	0.00	0.00	0.00	3.12	31	8.17	39.38

For the first project activity instance $\Delta C_{TREE_PROJ,t}$ is calculated based on the information of the previous table and on the following planting plan:

Table 11. Planting plan

	Plantation system				
Planting year	**Rubber**	**Forest plantation**	**AFS**	**Orchards**	**Total**
2013	38.90	63.09	22.49	1.52	126.00
2014	432.05	174.45	22.26	2.86	631.62
2015	432.43	337.18	37.01	60.09	866.71
2016	58.80	67.46	0.86	6.14	133.26
TOTAL	962.18	642.18	82.62	70.61	1,757.59

Table 12. Change in carbon stock in tree biomass in project

	$C_{TREE,t}$					$\Delta C_{TREE_PROJ,t}$
Project year	**Rubber**	**Forest**	**AFS**	**Orchards**	**Total**	**Total**
1	1,211.79	2,354.06	839.03	10.74	4,415.62	4,415.62
2	15,855.89	11,166.75	2,490.64	41.36	29,554.64	25,139.01
3	43,667.43	32,403.31	5,498.98	495.06	82,064.78	52,510.15
4	72,910.39	55,826.41	8,499.66	981.7	138,218.16	56,153.38
5	101,945.39	79,063.95	11,482.75	1,463.71	193,955.80	55,737.64
6	130,854.31	102,196.24	14,454.16	1,943.09	249,447.81	55,492.01
7	159,670.02	125,252.03	17,416.74	2,420.59	304,759.39	55,311.58
8	188,411.69	148,247.60	20,372.21	2,896.63	359,928.13	55,168.75
9	217,092.00	171,193.51	23,321.75	3,371.47	414,978.73	55,050.60
10	245,719.97	194,097.22	26,266.18	3,845.29	469,928.67	54,949.94
11	274,302.33	216,964.27	29,206.16	4,318.24	524,791.00	54,862.33
12	302,844.33	239,798.93	32,142.16	4,790.41	579,575.83	54,784.83
13	331,350.13	262,604.59	35,074.60	5,261.90	634,291.23	54,715.40
14	359,823.17	285,384.03	38,003.80	5,732.77	688,943.77	54,652.54
15	388,266.27	308,139.55	40,930.03	6,203.08	743,538.92	54,595.15
16	416,681.83	330,873.07	43,853.53	6,672.87	798,081.30	54,542.38
17	445,071.92	353,586.26	46,774.50	7,142.18	852,574.86	54,493.55
18	473,438.30	376,280.55	49,693.11	7,611.04	907,023.00	54,448.14
19	501,782.52	398,957.17	52,609.51	8,079.49	961,428.70	54,405.70
20	530,105.95	376,557.21	39,463.54	8,547.56	954,674.26	-6,754.44
21	558,409.80	274,733.12	26,522.26	9,015.26	868,680.45	-85,993.81
22	586,695.16	56,974.84	3,076.55	9,482.62	656,229.17	-212,451.28
23	614,962.99	32,403.31	5,498.98	9,949.65	662,814.94	6,585.77
24	643,214.18	55,826.41	8,499.66	10,416.37	717,956.63	55,141.69

	$C_{TREE,t}$					$\Delta C_{TREE_PROJ,t}$
Project year	**Rubber**	**Forest**	**AFS**	**Orchards**	**Total**	**Total**
25	671,449.52	79,063.95	11,482.75	10,882.80	772,879.02	54,922.39
26	699,669.73	102,196.24	14,454.16	11,348.95	827,669.08	54,790.07
27	727,875.49	125,252.03	17,416.74	11,814.83	882,359.09	54,690.01
28	756,067.40	148,247.60	20,372.21	12,280.46	936,967.67	54,608.57
29	784,246.02	171,193.51	23,321.75	12,745.84	991,507.12	54,539.45
30	777,823.42	194,097.22	26,266.18	12,905.95	1,011,092.78	19,585.66

Change in carbon stock in shrub biomass – $\Delta C_{SHRUB_PROJ,t}$

Ex-post, change in carbon stock in shrub in a year will be estimated following equation 25 of AR-TOOL14

$$\Delta C_{SHRUB,t} = \frac{C_{SHRUB,t2} - C_{SHRUB,t1}}{T} \times 1year$$

Where:

ΔC_{SHRUB} = Change in carbon stock in shrubs within the project boundary in year *t*; t CO2e

$C_{SHRUB,t2}$ = Carbon stock in shrubs within the project boundary at time *t2*; t CO2e.

$C_{SHRUB,t1}$ = Carbon stock in shrubs within the project boundary at time *t1*; t CO2e

T = Time elapsed between two successive estimations (T=*t*2 – *t*1); yr.

Note: Value of *T* does not have to be a whole number

Biomass of shrub is estimated following section 11 of AR-TOOL 14 "Estimating carbon stock in shrubs at a point of time". Equations 26 and 27 in this section are shown below:

$$C_{SHRUB,t} = \frac{44}{12} \times CF_S \times (1 + R_S) \times \sum A_{SHRUB,i} \times b_{SHRUB,i}$$

$$b_{SHRUB,i} = BDR_{SF} \times b_{FOREST} \times CC_{SHRUB,i}$$

Where:

$C_{SHRUB,t}$ = Carbon stock in shrubs within the project boundary at a given point of time in year t; t CO_2-e

CF_S = Carbon fraction of shrub biomass; t C (t.d.m.)$^{-1}$.

A default value of 0.47 is used unless transparent and

	verifiable information can be provided to justify a different value.
R_S	= Root-shoot ratio for shrubs; dimensionless. The default value of 0.40 is used unless transparent and verifiable information can be provided to justify a different value.
$A_{SHRUB,i}$	= Area of shrub biomass estimation stratum i; ha
$b_{SHRUB,i}$	= Shrub biomass per hectare in shrub biomass estimation stratum i; t d.m. ha^{-1}
BDR_{SF}	= Ratio of shrub biomass per hectare in land having a shrub crown cover of 1.0 (i.e. 100 per cent) and the default above-ground biomass content per hectare in forest in the region/country where the A/R CDM project activity is located; dimensionless. A default value of 0.10 is used unless transparent and verifiable information can be provided to justify a different value.
b_{FOREST}	Default above-ground biomass content in forest in the region/country where the A/R CDM project activity is located; t d.m. ha^{-1}.
$CC_{SHRUB,i}$	Crown cover of shrubs in shrub biomass estimation stratum i at the time of estimation, expressed as a fraction; dimensionless.

Ex-ante, following AR-TOOL 14 (Paragraph 13), change in carbon stock of shrubs may be estimated as zero.

Change in carbon stock in dead wood - $\Delta C_{DW_PROJ,t}$

Change in carbon stocks in dead wood in the project is estimated based on the A/R Methodological Tool “Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities” (Version 03.1), AR-TOOL 12.

The conservative default-factor based method for estimation of carbon stock in dead wood is selected for the assessment of this carbon pool. Following equation 9 of section 6.2 of this tool:

$$C_{DW,i,t} = C_{TREE,i,t} \times DF_{DW}$$

Where:

$C_{DW,i,t}$	= Carbon stock in dead wood in stratum *i* at a given point of time in year t; t CO_2-e.
$C_{TREE,i,t}$	= Carbon stock in trees biomass in stratum *i* at a point of time in year t; t CO_2-e.
DF_{DW}	= Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass; per cent.

For ex ante and ex post estimations in the first project activity instance, the conservative value for tropical biome, elevation below 2000 m and precipitation over 1600 mm[12] has been selected from the table 5 of section 8 of the tool, resulting a value of 6%.

Change in carbon stock in litter – $\Delta C_{LI_PROJ,t}$

Change in carbon stocks in dead wood in the project is estimated based on the A/R Methodological Tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities" (Version 03.1), AR-TOOL 12.

The conservative default-factor based method for estimation of carbon stock in litter is selected for the assessment of this carbon pool. Following equation 15 of section 7.2 of this tool:

$$C_{LI,i,t} = C_{TREE,i,t} \times DF_{LI}$$

Where:

$C_{LI,i,t}$	= Carbon stock in litter in stratum *i* at a given point of time in year t; t CO_2-e.
$C_{TREE,i,t}$	= Carbon stock in trees biomass in stratum *i* at a point of time in year t; t CO_2-e.
DF_{LI}	= Conservative default factor expressing carbon stock in litter as a percentage of carbon stock in tree biomass; per cent.

For ex ante and ex post estimations in the first project activity instance, the conservative value for tropical biome, elevation below 2000 m and precipitation over 1600 mm has been selected from the table 6 of section 8 of the tool, resulting a value of 1%.

[12] http://www.insivumeh.gob.gt/hidrologia/ATLAS_HIDROMETEOROLOGICO/Atlas_Hidrologico/isoyetas.jpg

Change in carbon stock in the soil organic carbon (SOC) - $\Delta C_{SOC_PROJ,t}$

Changes in carbon stocks in the SOC pool is calculated as indicate in the A/R Methodological "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities" (Version 01.1.0).

The change in SOC stock for all the strata of the areas of land, in year t, is calculated applying equation 8:

$$\Delta SOC_{AL,t} = \frac{44}{12} \times \sum_{t=1}^{t} A_i \times dSOC_{t,i} \times 1year$$

Where:

$\Delta SOC_{AL,t}$	= Change in SOC stock in areas of land meeting the applicability conditions of this tool, in year *t*; t CO2-e.
A_i	= The area of stratum *i* of the areas of land; ha.
$dSOC_{t,i}$	= The rate of change in SOC stocks in stratum *i* of the areas of land; t C ha^{-1} yr^{-1}.

$$dSOC_{t,i} = \frac{SOC_{REF,i} - (SOC_{INITIAL,i} - SOC_{LOSS,i})}{20\ years} \quad for\ t_{PREP,i} < t \leq t_{PREP,i} + 20$$

Where:

$dSOC_{t,i}$	= The rate of change in SOC stock in stratum *i* of the areas of land, in year *t*; t C ha^{-1} yr^{-1}.
$t_{PREP,i}$	= The year in which first soil disturbance takes place in stratum *i* of the areas of land.
$SOC_{LOSS,i}$	= Loss of SOC caused by soil disturbance attributable the A/R CDM project activity, in stratum *i* of the areas of land; t C ha^{-1}.
$SOC_{REF,i}$	Reference SOC stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation . normally forest) by climate region and soil type applicable to stratum *i* of the areas of land; t C ha^{-1}.
$SOC_{INITIAL,i}$	SOC stock at the beginning of the A/R CDM project activity in stratum *i* of the areas of land; t C ha^{-1}.

Following equation 3 of the tool $SOC_{LOSS,i} = 0$ in all baseline strata. The area disturbed in the baseline is less than 10% of the stratum area. This is because soil preparation is made by manual hole digging in less than 10% of the plantation area.

$$SOC_{INITIAL,i} = SOC_{REF,i} \times f_{LU,i} \times f_{MG,i} \times f_{IN,i}$$

Where:

$f_{LU,i}$	= Relative stock change factor for baseline land-use in stratum *i* of the areas of land; dimensionless.
$f_{MG,i}$	= Relative stock change factor for baseline management regime in stratum *i* of the areas of land; dimensionless.
$f_{IN,i}$	= Relative stock change factor for baseline input regime (e.g. crop residue returns, manure) in stratum *i* of the areas of land; dimensionless.

For ex ante estimations SOC_{REF} and stock change factors (f_{LU}, f_{MG} and f_{IN}) have been obtained from tables 3, 4, 5 and 6 of the tool.

- SOC_{REF}: 60. Value from table 3 for tropical wet climate region and LAC soils (Soils with low activity clay)
- f_{LU}:
    - Cropland: 0.57. Value calculated based on values of table 4. 73% of the cropland area with long term cultivation (0.48) and 27% with short term cultivation or set aside in tropical wet climate region (0.82)
    - Grassland: 1. Value from table 6, unique value.
- f_{MG}:
    - Cropland: 1.15. Value from table 6, reduced tillage in tropical wet climate region
    - Grassland: 0.7. Value from table 6, severely degraded lands
- f_{IN}:
    - Cropland: 0.92. Value from table 5, low nutrient input in tropical wet climate region
    - Grassland: 1. Value from table 6, low nutrient input in tropical wet climate region

Ex ante estimations for the first project activity instance have been done considering the values of previous list and the planting plan:

Table 14. Initial land use vs. planting year

	Planting year				
Initial land use	**2013**	**2014**	**2015**	**2016**	**Total (ha)**
Cropland	60.52	352.63	541.76	125.09	1080.01
Grassland	65.48	278.99	324.95	8.18	677.59
Total	126.00	631.62	866.71	133.26	1,757.59

Table 15. Change in SOC stock

Project year	**SOC stock per planting year (tCO_2)**					**$\Delta SOC_{AL,t}$**
	2013	**2014**	**2015**	**2016**	**Total**	
1	369.59				**369.59**	**369.59**
2	739.18	1,852.76			**2,591.93**	**2,222.35**
3	1,108.77	3,705.51	2,542.35		**7,356.63**	**4,764.70**
4	1,478.35	5,558.27	5,084.70	390.91	**12,512.24**	**5,155.61**
5	1,847.94	7,411.03	7,627.06	781.82	**17,667.85**	**5,155.61**
6	2,217.53	9,263.78	10,169.41	1,172.73	**22,823.45**	**5,155.61**
7	2,587.12	11,116.54	12,711.76	1,563.64	**27,979.06**	**5,155.61**
8	2,956.71	12,969.30	15,254.11	1,954.55	**33,134.67**	**5,155.61**
9	3,326.30	14,822.05	17,796.46	2,345.46	**38,290.28**	**5,155.61**
10	3,695.89	16,674.81	20,338.81	2,736.37	**43,445.88**	**5,155.61**
11	4,065.48	18,527.57	22,881.17	3,127.28	**48,601.49**	**5,155.61**
12	4,435.06	20,380.32	25,423.52	3,518.20	**53,757.10**	**5,155.61**
13	4,804.65	22,233.08	27,965.87	3,909.11	**58,912.71**	**5,155.61**
14	5,174.24	24,085.84	30,508.22	4,300.02	**64,068.31**	**5,155.61**
15	5,543.83	25,938.59	33,050.57	4,690.93	**69,223.92**	**5,155.61**
16	5,913.42	27,791.35	35,592.92	5,081.84	**74,379.53**	**5,155.61**
17	6,283.01	29,644.10	38,135.28	5,472.75	**79,535.14**	**5,155.61**
18	6,652.60	31,496.86	40,677.63	5,863.66	**84,690.74**	**5,155.61**
19	7,022.18	33,349.62	43,219.98	6,254.57	**89,846.35**	**5,155.61**
20	7,391.77	35,202.37	45,762.33	6,645.48	**95,001.96**	**5,155.61**
21	7,391.77	37,055.13	48,304.68	7,036.39	**99,787.98**	**4,786.02**
22	7,391.77	37,055.13	50,847.03	7,427.30	**102,721.24**	**2,933.26**
23	7,391.77	37,055.13	50,847.03	7,818.21	**103,112.15**	**390.91**
24	7,391.77	37,055.13	50,847.03	7,818.21	**103,112.15**	**0.00**
25	7,391.77	37,055.13	50,847.03	7,818.21	**103,112.15**	**0.00**
26	7,391.77	37,055.13	50,847.03	7,818.21	**103,112.15**	**0.00**
27	7,391.77	37,055.13	50,847.03	7,818.21	**103,112.15**	**0.00**
28	7,391.77	37,055.13	50,847.03	7,818.21	**103,112.15**	**0.00**
29	7,391.77	37,055.13	50,847.03	7,818.21	**103,112.15**	**0.00**
30	7,391.77	37,055.13	50,847.03	7,818.21	**103,112.15**	**0.00**

Increase of non-CO_2 GHG emissions within the project boundary - $GHG_{E,t}$

Increase of non-CO_2 GHG emissions is estimated using the CDM A/R Methodological Tool "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity". Following equation 1 of the tool:

$$GHG_{e,t} = GHG_{SPF,t} + GHG_{FMF,t} + GHG_{FF,t}$$

Where:

$GHG_{e,t}$	= Emission of non-CO_2 GHGs resulting from burning of biomass and forest fires within the project boundary in year *t*; t CO_2-e.
$GHG_{SPF,t}$	= Emission of non-CO_2 GHGs resulting from use of fire in site preparation in year *t*; t CO_2-e.
$GHG_{FMF,t}$	= Emission of non-CO_2 GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land or other forest management, in year *t*; t CO_2-e.
$GHG_{FF,t}$	= Emission of non-CO_2 GHGs resulting from fire in year *t*; t CO_2-e.

It can be assumed that emissions of non-CO_2 GHGs resulting from use of fire in site preparation in year t are zero (***$GHG_{SPF,t}$* = 0**) following in the tool (Paragraph 7, a): *For all areas of land where: (i) Slash-and-burn is a common practice in the baseline, and (ii) Fire has been used in the area at least once during the period of ten years preceding the start of the A/R CDM project activity:* $GHG_{SPF,t}$ = 0.

Emissions of non-CO2 GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land is estimated using equations 4 and 5 of the tool.

$$GHG_{FMF,t} = 0.07 \times \frac{44}{12} \times B_{HARVEST,t} \times f_{BL} \times CF_{TREE}$$

Where:

$GHG_{FMF,t}$	= Emission of non-CO*2* GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land, in year *t*; t CO*2*-e.
$B_{HARVEST,t}$	= Biomass harvested from area subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year *t*; t d.m.
f_{BL}	= The fraction of aboveground tree biomass out of total harvest left on-site; dimensionless. A value of 0.25 for tropical forest is used. These values of the parameter

have been conservatively adapted from Table 3A.1.11 of the IPCC GPG LULUCF 2003.

CF_{TREE} = Carbon fraction of biomass of trees harvested; t C (t d.m)$^{-1}$. IPCC default value of 0.50 t C (t d.m)-1 is used.

$$B_{HARVEST,t} = \frac{b_{FOREST}}{BEF_2} \times A_{FMF,t}$$

Where:

B_{FOREST} = Default above-ground biomass content in forest in the region/country where the A/R CDM project is located; t d.m. ha^{-1}.

BEF_2 = The biomass expansion factor for trees harvested; dimensionless. A value of 1.25 is used.

$A_{FMF,t}$ = Area of land subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year *t*; ha.

Fire will not be used to clear the land of harvest residues, therefore ***GHG$_{FMF,t}$* = 0.**

If forest fires occur they will be reported and monitored. Emission of non-CO2 GHGs resulting from forest fire ($GHG_{FF,t}$) will be calculated ex-post using specifically equations 6, 7 and 8 of the mentioned A/R CDM Methodological tool.

$$GHG_{FF,t} = GHG_{FF_TREE,t} + GHG_{FF_DOM,t}$$ Equation 6 of the tool.

$$GHG_{FF_TREE,t} = 0.001 \times \sum_{i=1}^{M} A_{BURN,i,t} \times b_{TREE,i,t_L} \times COMF_i \times \left(EF_{CH4,i} \times GWP_{CH4} + EF_{N20,i} \times GWP_{N20}\right)$$

Equation 7 of the tool.

$$GHG_{FF_DOM,t} = 0.07 \times \sum_{i=1}^{M} A_{BURN,i,t} \times \left(C_{DW,i,t_L} + C_{LI,i,t_L}\right)$$ Equation 8 of the tool.

Where:

$GHG_{FF_TREE,t}$ = Emission of non-CO2 GHGs resulting from the loss of aboveground biomass of trees due to forest fire, in year *t*; t CO_2-e.

$GHG_{FF_DOM,t}$ = Emission of non-CO2 GHGs resulting from the loss of dead organic matter due to forest fire, in year *t*; t CO2-e.

$A_{BURN,i,t}$ = Area burnt in stratum *i* in year *t*; ha.

b_{TREE,i,t_L}	= Mean aboveground tree biomass per hectare in stratum *i* in year t_L which is the year in which last verification was carried out before occurrence of the fire; t d.m. ha^{-1} Where aboveground biomass of living trees is not burnt by fire b_{TREE,i,t_L} may be set equal to zero.
$COMF_i$	= Combustion factor for stratum *i*; dimensionless.
$EF_{CH4,i}$	= Emission factor for CH4 in stratum *i*; g CH_4 (kg dry matter burnt)$^{-1}$.
GWP_{CH4}	= Global warming potential for CH_4; dimensionless Default value of 21 is used.
$EF_{N20,i}$	= Emission factor for N_2O in stratum *i*; g N_2O (kg dry matter burnt)$^{-1}$.
GWP_{N20}	= Global warming potential for N_2O; dimensionless Default value of 310 is used.
C_{DW,i,t_L}	= Carbon stock in dead wood in stratum *i* in year t_L which is the year in which last verification was carried out before occurrence of the fire, as estimated using the .Tool for estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities.; t CO_2-e.
C_{LI,i,t_L}	= Carbon stock in litter in stratum *i* in year t_L which is the year in which last verification was carried out before occurrence of the fire, as estimated using the .Tool for estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities.; t CO_2-e.

For ex ante estimations emission of non-CO_2 GHGs resulting from fires will be considered zero, $\boldsymbol{GHG_{FF,t} = 0}$. There is no information about forest fire inside the project area, therefore in the ex-ante estimations it is not possible to estimate potential emissions due to this type of fires.

Actual net greenhouse gas removals by sinks - $\Delta C_{ACTUAL,t}$

The ex-ante actual net GHG removals by sink are calculated in an Excel file available to VVB on request (Ex ante GHG_assessment.xls), based on equation 2 of the methodoloy ($\Delta C_{ACTUAL,t} = \Delta C_{P,t} - GHG_{E,t}$), where $GHG_{E,t} = 0$ and therefore $\Delta C_{ACTUAL,t} = \Delta C_{P,t}$. Summary result of $\Delta C_{ACTUAL,t}$ are included in the following table.

Table 16. Ex ante actual net GHG removals by sinks

Project year	Tree biomass carbon pool		Dead wood carbon pool		Litter carbon pool		Soil organic carbon pool		Actual net GHG removals by sinks	
	Annual carbon stock change $\Delta C_{TREE_PROJ,t}$	Cumulative carbon stock change	Annual carbon stock change	Cumulative carbon stock change	Annual carbon stock change	Cumulative carbon stock change	Annual carbon stock change	Cumulative carbon stock change	Annual carbon stock change	Cumulative carbon stock change
year	$tCO_2e\ yr^{-1}$	tCO_2e	$tCO_2e\ yr^{-1}$	tCO_2e	$tCO_2e\ yr^{-1}$	tCO_2e	$tCO_2e\ yr^{-1}$	tCO_2e	$tCO_2e\ yr^{-1}$	tCO_2e
2013	4,415.62	4,415.62	264.94	264.94	44.16	44.16	369.59	369.59	5,094.30	5,094.30
2014	25,139.01	29,554.64	1,508.34	1,773.28	251.39	295.55	2,222.35	2,591.93	29,121.09	34,215.39
2015	52,510.15	82,064.78	3,150.61	4,923.89	525.10	820.65	4,764.70	7,356.63	60,950.55	95,165.95
2016	56,153.38	138,218.16	3,369.20	8,293.09	561.53	1,382.18	5,155.61	12,512.24	65,239.72	160,405.67
2017	55,737.64	193,955.80	3,344.26	11,637.35	557.38	1,939.56	5,155.61	17,667.85	64,794.88	225,200.55
2018	55,492.01	249,447.81	3,329.52	14,966.87	554.92	2,494.48	5,155.61	22,823.45	64,532.05	289,732.61
2019	55,311.58	304,759.39	3,318.69	18,285.56	553.12	3,047.59	5,155.61	27,979.06	64,339.00	354,071.60
2020	55,168.75	359,928.13	3,310.12	21,595.69	551.69	3,599.28	5,155.61	33,134.67	64,186.17	418,257.77
2021	55,050.60	414,978.73	3,303.04	24,898.72	550.51	4,149.79	5,155.61	38,290.28	64,059.75	482,317.52
2022	54,949.94	469,928.67	3,297.00	28,195.72	549.50	4,699.29	5,155.61	43,445.88	63,952.04	546,269.56
2023	54,862.33	524,791.00	3,291.74	31,487.46	548.62	5,247.91	5,155.61	48,601.49	63,858.30	610,127.86
2024	54,784.83	579,575.83	3,287.09	34,774.55	547.85	5,795.76	5,155.61	53,757.10	63,775.38	673,903.24
2025	54,715.40	634,291.23	3,282.92	38,057.47	547.15	6,342.91	5,155.61	58,912.71	63,701.08	737,604.32
2026	54,652.54	688,943.77	3,279.15	41,336.63	546.53	6,889.44	5,155.61	64,068.31	63,633.83	801,238.15
2027	54,595.15	743,538.92	3,275.71	44,612.34	545.95	7,435.39	5,155.61	69,223.92	63,572.42	864,810.57
2028	54,542.38	798,081.30	3,272.54	47,884.88	545.42	7,980.81	5,155.61	74,379.53	63,515.96	928,326.52
2029	54,493.55	852,574.86	3,269.61	51,154.49	544.94	8,525.75	5,155.61	79,535.14	63,463.71	991,790.23
2030	54,448.14	907,023.00	3,266.89	54,421.38	544.48	9,070.23	5,155.61	84,690.74	63,415.11	1,055,205.35
2031	54,405.70	961,428.70	3,264.34	57,685.72	544.06	9,614.29	5,155.61	89,846.35	63,369.71	1,118,575.06
2032	-6,754.44	954,674.26	-405.27	57,280.46	-67.54	9,546.74	5,155.61	95,001.96	-2,071.64	1,116,503.42
2033	-85,993.81	868,680.45	-5,159.63	52,120.83	-859.94	8,686.80	4,786.02	99,787.98	-87,227.36	1,029,276.06

Project year	Tree biomass carbon pool		Dead wood carbon pool		Litter carbon pool		Soil organic carbon pool		Actual net GHG removals by sinks	
	Annual carbon stock change $\Delta C_{TREE_PROJ,t}$	Cumulative carbon stock change	Annual carbon stock change	Cumulative carbon stock change	Annual carbon stock change	Cumulative carbon stock change	Annual carbon stock change	Cumulative carbon stock change	Annual carbon stock change	Cumulative carbon stock change
year	$tCO_2e\ yr^{-1}$	tCO_2e	$tCO_2e\ yr^{-1}$	tCO_2e	$tCO_2e\ yr^{-1}$	tCO_2e	$tCO_2e\ yr^{-1}$	tCO_2e	$tCO_2e\ yr^{-1}$	tCO_2e
2034	-212,451.28	656,229.17	-12,747.08	39,373.75	-2,124.51	6,562.29	2,933.26	102,721.24	-224,389.61	804,886.45
2035	6,585.77	662,814.94	395.15	39,768.90	65.86	6,628.15	390.91	103,112.15	7,437.68	812,324.13
2036	55,141.69	717,956.63	3,308.50	43,077.40	551.42	7,179.57	0.00	103,112.15	59,001.61	871,325.74
2037	54,922.39	772,879.02	3,295.34	46,372.74	549.22	7,728.79	0.00	103,112.15	58,766.96	930,092.70
2038	54,790.07	827,669.08	3,287.40	49,660.15	547.90	8,276.69	0.00	103,112.15	58,625.37	988,718.07
2039	54,690.01	882,359.09	3,281.40	52,941.55	546.90	8,823.59	0.00	103,112.15	58,518.31	1,047,236.38
2040	54,608.57	936,967.67	3,276.51	56,218.06	546.09	9,369.68	0.00	103,112.15	58,431.17	1,105,667.55
2041	54,539.45	991,507.12	3,272.37	59,490.43	545.39	9,915.07	0.00	103,112.15	58,357.21	1,164,024.77
2042	19,585.66	1,011,092.78	1,175.14	60,665.57	195.86	10,110.93	0.00	103,112.15	20,956.66	1,184,981.42

3.3 Leakage

The only leakage emission source considered in the selected methodology is leakage due to the displacement of agricultural activities, and must be calculated using the tool AR-TOOL15 "Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity". According to equation 1 of this tool:

$$LK_{AGRIC,t} = \frac{44}{12} \times \left(\Delta C_{BIOMASS,t} + \Delta SOC_{LUC,t}\right)$$

Where:

$LK_{AGRIC,t}$	= Leakage emission resulting from displacement of agricultural activities in year *t*; t CO2e.
$\Delta C_{BIOMASS,t}$	= Decrease in carbon stock in the carbon pools of the land receiving the activity displaced in year *t*; t d.m..
$\Delta SOC_{LUC,t}$	= Change in soil organic carbon (SOC) stock due to land-use change in the land receiving the displaced activity in year *t*; tC ha-*1*. The value of this parameter may be set to zero if: (a) The only displaced activity being received in the land is grazing activity; or (b) The value of the parameter as estimated from Equation (3) of this tool is less than zero (i.e. negative).

Equations 2 and 3 of AR-TOOL 15 are used to estimate the decrease in carbon stock in the carbon pools of the land receiving the activity displaced in year *t* and the change in SOC stock due to land-use change in the land receiving the displaced activity in year *t.*

$$\Delta C_{BIOMASS,t} = [1.1 \times b_{TREE} \times (1 + R_{TREE}) + b_{SHRUB} \times (1 + R_s)] \times CF \times A_{DISP,t}$$

$$\Delta SOC_{LUC,t} = SOC_{REF} \times \left(f_{LUP} \times f_{MGP} \times f_{INP} - f_{LUD} \times f_{MGD} \times f_{IND}\right) \times A_{DISP,t}$$

Where:

b_{TREE}	= Mean above-ground tree biomass in land receiving the displaced activity; t d.m. ha^{-1} The value of this parameter is obtained by applying one of the applicable methods from the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" to the land receiving the displaced activity. Where the land receiving the displaced activity is unidentified, value of is set equal to the applicable

	value of mean above-ground biomass in forest in the region or country where the A/R CDM project activity is located, as obtained from Table 3A.1.4 of the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC GPG-LULUCF 2003).
R_{TREE}	= Root-shoot ratio for trees in the land receiving the displaced activity; dimensionless. A default value of 0.25 is used.
b_{SHRUB}	= Mean above-ground shrub biomass in land receiving the displaced activity; t d.m. ha^{-1}. The value of this parameter is obtained by applying one of the applicable methods from the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" to the land receiving the displaced activity.
R_s	Root-shoot ratio for shrubs in the land receiving the displaced activity; dimensionless. The default value of 0.40 is used.
CF	Carbon fraction of woody biomass; dimensionless. A default value of 0.47 is used.
$A_{DISP,t}$	Area of land from which agricultural activity is being displaced in year *t*; ha
SOC_{REF}	SOC stock corresponding to the reference condition in native lands by climate region and soil type applicable to the land receiving the displaced activity; t C ha-1. The value of this parameter is taken from Table 3 of the "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities"
$f_{LUP}, f_{MGP}, f_{INP}$	Relative SOC *stock change factors* for land-use, management practices, and inputs respectively, applicable to the receiving land after the displaced activity has been received; dimensionless. The value of these parameters is taken from Tables 4, 5, and 6 of the "Tool for estimation of change in soil organic carbon stocks due to the implementation

of A/R CDM project activities".

$f_{LUD}, f_{MGD}, f_{IND}$ — Relative SOC *stock change factors* for land-use, management practices, and inputs respectively, applicable to the receiving land after the displaced activity has been received; dimensionless.

The value of these parameters is taken from Tables 4, 5, and 6 of the "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities".

No leakage is expected in the first project activity instance. Displacement of pre-project agricultural activities is not expected and if it occurs it will be to lands with SOC and biomass stocks equal or lower to the ones in original agriculture lands. Therefore, leakage in the first instance will be set equal to zero ($LK_{,t}$ =0).

In future project activity instances, if displacement of agricultural activities occurs, then leakage will be calculated using AR-TOOL15.

3.4 Estimated Net GHG Emission Reductions and Removals

Table 17. Estimated Net GHG Emission Reductions and Removals

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2013	0,00	5,094.30	0.00	5,094.30
2014	0,00	29,121.09	0.00	29,121.09
2015	0,00	60,950.55	0.00	60,950.55
2016	0,00	65,239.72	0.00	65,239.72
2017	0,00	64,794.88	0.00	64,794.88
2018	0,00	64,532.05	0.00	64,532.05
2019	0,00	64,339.00	0.00	64,339.00
2020	0,00	64,186.17	0.00	64,186.17
2021	0,00	64,059.75	0.00	64,059.75
2022	0,00	63,952.04	0.00	63,952.04
2023	0,00	63,858.30	0.00	63,858.30
2024	0,00	63,775.38	0.00	63,775.38
2025	0,00	63,701.08	0.00	63,701.08
2026	0,00	63,633.83	0.00	63,633.83
2027	0,00	63,572.42	0.00	63,572.42
2028	0,00	63,515.96	0.00	63,515.96
2029	0,00	63,463.71	0.00	63,463.71
2030	0,00	63,415.11	0.00	63,415.11
2031	0,00	63,369.71	0.00	63,369.71

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2032	0,00	-2,071.64	0.00	-2,071.64
2033	0,00	-87,227.36	0.00	-87,227.36
2034	0,00	-224,389.61	0.00	-224,389.61
2035	0,00	7,437.68	0.00	7,437.68
2036	0,00	59,001.61	0.00	59,001.61
2037	0,00	58,766.96	0.00	58,766.96
2038	0,00	58,625.37	0.00	58,625.37
2039	0,00	58,518.31	0.00	58,518.31
2040	0,00	58,431.17	0.00	58,431.17
2041	0,00	58,357.21	0.00	58,357.21
2042	0,00	20,956.66	0.00	20,956.66
Total	**0,00**	1,184,981.42	**0.00**	1,184,981.42

Following sections 3.1.9 of AFOLU Requirements v3.5, as this is an ARR or IFM projects with harvesting activities, it is necessary to calculate the long-term average GHG benefit maintained by the project. It is necessary to demonstrate that GHG credits are not issued above this value. Calculations of the long-term average GHG benefit have been done following Section 4.5.5. of AFOLU Requirements v3.5 in the Excel file “Ex_ante_GHG_assessment” (worksheet Long Term Average). The long-term average GHG benefit maintained by this project is 698,310 tCO_2e.

4 MONITORING

4.1 Data and Parameters Available at Validation

Table 18. Data and parameters available at validation

Data / Parameter	$\Delta C_{BSL,t}$
Data unit	t CO2-e
Description	Baseline net GHG removals by sinks in year t
Source of data	See section 3
Value applied:	0
Justification of choice of data or description of measurement methods and procedures applied	Value based on section 5.4 of the methodology AR ACM0003 (Version 02.0)
Purpose of Data	Calculation of ex-ante and ex-post baseline emissions
Comments	See section 3

Data / Parameter	CF_{TREE}
Data unit	t C (t d.m.)$^{-1}$
Description	Carbon fraction of tree biomass
Source of data	AR-TOOL14
Value applied:	0.47
Justification of choice of data or description of measurement methods and procedures applied	Default value of AR-TOOL14 is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	R_j
Data unit	dimensionless
Description	Root-shoot ratio for tree species j
Source of data	AR-TOOL14
Value applied:	Result of the application of the following equation: R_j=exp[-1.085+0.9256*ln(AGB)]/AGB

	Where AGB is the above-ground tree biomass per hectare (in t d.m. ha^{-1}),
Justification of choice of data or description of measurement methods and procedures applied	Default equation suggested in AR-TOOL14 is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	$V_{TREE,j}(x_{1,l}, x_{2,l}, x_{3,l}, \dots)$
Data unit	m^3
Description	Stem volume of tree *l* of species *j* in sample plot *p* of stratum i, estimated from the tree dimension(s) as entry data into a volume table or volume equation
Source of data	Application of the equation to monitoring tree data
Value applied:	Result of the application of the equation
Justification of choice of data or description of measurement methods and procedures applied	AR-TOOL14
Purpose of Data	Calculation of ex-post project emissions/removals
Comments	-

Data / Parameter	D_j
Data unit	t d.m. m^{-3}
Description	Density (over-bark) of tree species *j*
Source of data	Table 3A.1.9 of IPCC GPG-LULUCF 2003; Table 4.13 (Volume 4) IPCC Guidelines for national GHG inventories 2006; Chave J, Coomes DA, Jansen S, Lewis SL, Swenson NG, Zanne AE (2009) Towards a worldwide wood economics spectrum. Ecology Letters 12(4): 351-366; and Worldwide 'Open Access' Tree Functional Attributes and Ecological Database (http://db.worldagroforestry.org). (See Excel file "Field data and calculations")
Value applied:	Depending on tree species (See Excel file "Field data and calculations")
Justification of choice of data or description of	Default value is used unless transparent and verifiable information can be provided to justify different values.

measurement methods and procedures applied	
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	$BEF_{2,j}$
Data unit	dimensionless
Description	Biomass expansion factor for conversion of tree stem biomass to above-ground tree biomass, for tree species *j*
Source of data	Forest species: Montero, M., & Montagnini, F. (2005). Modelos alométricos para la estimación de biomasa de diez especies nativas en plantaciones en la región Atlántica de Costa Rica. Rubber: Rivera, C. M., & Chaidez, J. D. J. N. (2004). Ecuaciones de aditividad para estimar componentes de biomasa de Hevea brasiliensis Muell. Arg., en Veracruz, México. Madera y Bosques, 10(2), 29-43. Agroforestry species: AR-TOOL14 default value
Value applied:	Forest species: 1.42 Rubber: 1.52 Agroforestry species: 1.15
Justification of choice of data or description of measurement methods and procedures applied	BEF_2 values for Ruber and Forest species are different than the default value of AR-TOOL 14 (1.15). Transparent and verifiable information have been found in the abovementioned sources to justify the choice of different values.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	CF_S
Data unit	t C (t.d.m.)$^{-1}$
Description	Carbon fraction of shrub biomass
Source of data	AR-TOOL14
Value applied:	0.47
Justification of choice of data or description of measurement methods and procedures applied	A default value of is used unless transparent and verifiable information can be provided to justify a different value
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals

Comments	-

Data / Parameter	R_S
Data unit	dimensionless
Description	Root-shoot ratio for shrubs
Source of data	AR-TOOL14
Value applied:	0.40
Justification of choice of data or description of measurement methods and procedures applied	The default value is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	BDR_{SF}
Data unit	dimensionless
Description	Ratio of shrub biomass per hectare in land having a shrub crown cover of 1.0 (i.e. 100 per cent) and the default above-ground biomass content per hectare in forest in the region/country where the A/R CDM project activity is located.
Source of data	AR-TOOL14
Value applied:	0.10
Justification of choice of data or description of measurement methods and procedures applied	A default value is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	b_{FOREST}
Data unit	t d.m. ha^{-1}
Description	Default above-ground biomass content in forest in the region/country where the A/R CDM project is located
Source of data	Table 3A.1.4 of IPCC GPG-LULUCF 2003
Value applied:	371

Justification of choice of data or description of measurement methods and procedures applied	Default values from Table 3A.1.4 of IPCC GPG-LULUCF 2003
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	DF_{DW}
Data unit	per cent
Description	Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass
Source of data	AR-TOOL12, Data / Parameter table 5.
Value applied:	6
Justification of choice of data or description of measurement methods and procedures applied	The most conservative value for tropical biome, elevation below 2000 m and precipitation over 1600mm has been selected from the table.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	DF_{LI}
Data unit	per cent
Description	Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass
Source of data	AR-TOOL12, Data / Parameter table 6.
Value applied:	1
Justification of choice of data or description of measurement methods and procedures applied	The most conservative value for tropical biome, elevation below 2000 m and precipitation over 1600mm has been selected from the table.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	f_{BL}
Data unit	dimensionless
Description	Fraction of aboveground tree biomass out of total harvest left on-

	site
Source of data	Table 3A.1.11 of the IPCC GPG LULUCF 2003.
Value applied:	0.25
Justification of choice of data or description of measurement methods and procedures applied	A conservatively adapted value for tropical forest is used.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals
Comments	-

Data / Parameter	$COMF_i$
Data unit	dimensionless
Description	Combustion factor for stratum *i*
Source of data	CDM A/R Methodological Tool "Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	Default value depending on the age: 3-5 years = 0.46; 6-10 years = 0.67; 11-17 years = 0.5 ; ≥ 18 years = 0.32 (unless transparent and verifiable information can be provided to justify a different value)
Justification of choice of data or description of measurement methods and procedures applied	Default emission factor for tropical forest from the CDM A/R tool. If transparent and verifiable information can be provided, then different values may be selected from the following sources, in order of preference; (a) Project-specific calculation, regional/national inventories e.g. national forest inventory, national GHG inventory; (b) Inventory from neighbouring countries with similar conditions; (c) Globally available data applicable to the project site or to the region/country where the site is located
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	$EF_{CH4,i}$
Data unit	g kg^{-1} dry matter burnt
Description	Emission factor for CH4 in stratum *i*
Source of data	CDM A/R Methodological Tool "Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	6.8 (unless transparent and verifiable information can be provided

	to justify a different value)
Justification of choice of data or description of measurement methods and procedures applied	Default emission factor for tropical forest from the CDM A/R tool. If transparent and verifiable information can be provided, then different values may be selected from the following sources, in order of preference; (a) Project-specific calculation, regional/national inventories e.g. national forest inventory, national GHG inventory; (b) Inventory from neighbouring countries with similar conditions; (c) Globally available data applicable to the project site or to the region/country where the site is located (d) Default values as follows: Tropical forest=6.8
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	GWP_{CH4}
Data unit	dimensionless
Description	Global warming potential for CH_4
Source of data	CDM A/R Methodological Tool "Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	21
Justification of choice of data or description of measurement methods and procedures applied	Default value in the CDM A/R Methodological Tool.
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	$EF_{N2O,i}$
Data unit	g kg^{-1} dry matter burnt
Description	Emission factor for N_2O in stratum *i*;
Source of data	CDM A/R Methodological Tool "Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	0.20
Justification of choice of data or description of measurement methods	Default emission factor for tropical forest from the CDM A/R tool. If transparent and verifiable information can be provided, then different values may be selected from the following sources, in order of preference;

and procedures applied	(a) Regional/national inventories e.g. national forest inventory, national GHG inventory; (b) Inventory from neighbouring countries with similar conditions; (c) Globally available data applicable to the project site or to the region/country where the site is located; (d) Default values as follows: Tropical forest=0.20
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	GWP_{N2O}
Data unit	dimensionless
Description	Global warming potential for N_2O
Source of data	CDM A/R Methodological Tool "Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" (Version 04.0.0)
Value applied:	310
Justification of choice of data or description of measurement methods and procedures applied	Default value in the CDM A/R Methodological Tool.
Purpose of Data	Calculation of ex-post project emissions
Comments	-

Data / Parameter	SOC_{REF}
Data unit	t C ha^{-1}
Description	SOC stock corresponding to the reference condition in native lands by climate region and soil type applicable to the land receiving the displaced activity.
Source of data	The value of this parameter is taken from Table 3 of the "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities"
Value applied:	60
Justification of choice of data or description of measurement methods and procedures applied	Default reference SOC stocks value for tropical wet biome and soils with low activity clay (LAC) minerals.
Purpose of Data	Calculation of project emissions/removals and leakage (ex-ante

	and ex-post)
Comments	-

Data / Parameter	f_{LU}
Data unit	dimensionless
Description	Relative SOC *stock change factors* for baseline land-use.
Source of data	A/R CDM Tool 'tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities'
Value applied:	Cropland: 0.82 for short term cultivation and 0.48 for long term cultivation Grassland: 1
Justification of choice of data or description of measurement methods and procedures applied	Cropland: Value from table 4 of the tool, short term cultivation or set aside in tropical wet climate region Grassland: Value from table 6 of the tool, unique value.
Purpose of Data	Calculation of project emissions/removals and leakage (ex-ante and ex-post)
Comments	For leakage calculation different values may be applied depending on the characteristics of potential displacements

Data / Parameter	f_{MG}
Data unit	dimensionless
Description	Relative SOC *stock change factors* for baseline management.
Source of data	A/R CDM Tool 'tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities'
Value applied:	Cropland: 1.15 Grassland: 0.7
Justification of choice of data or description of measurement methods and procedures applied	Cropland: Value from table 6of the tool, reduced tillage in tropical wet climate region Grassland: Value from table 6 of the tool, severely degraded lands
Purpose of Data	Calculation of project emissions/removals and leakage (ex-ante and ex-post)

Comments	For leakage calculation different values may be applied depending on the characteristics of potential displacements

Data / Parameter	f_{IN}
Data unit	dimensionless
Description	Relative SOC *stock change factors* for baseline inputs regime.
Source of data	A/R CDM Tool 'tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities'
Value applied:	Cropland: 0.92 Grassland: 1
Justification of choice of data or description of measurement methods and procedures applied	Cropland: Value from table 5 of the tool, low nutrient input in tropical wet climate region Grassland: Value from table 6 of the tool, low nutrient input in tropical wet climate region.
Purpose of Data	Calculation of project emissions/removals and leakage (ex-ante and ex-post)
Comments	For leakage calculation different values may be applied depending on the characteristics of potential displacements

4.2 Data and Parameters Monitored

Table 19. Data and parameters monitored

Data / Parameter	A_i
Data unit	ha
Description	Area of tree biomass estimation stratum *i*
Source of data	GIS or/and GPS
Description of measurement methods and procedures to be applied	Areas in project area will be tracked in the field using the GPS.
Frequency of monitoring/recording	Before the start of the project (planting) and adjusted thereafter every monitoring since the year of the initial verification
Value applied:	See section 1.9 of this PD including the stratification.
Monitoring equipment	GPS (Garmin), GPS Smartphones and GIS.

QA/QC procedures to be applied	Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible; all field team members are trained in GPS/GIS application
Purpose of data	Calculation of project emissions/removals
Calculation method	GIS tool
Comments	-

Data / Parameter	$A_{SHRUB,i}$
Data unit	ha
Description	Area of shrub biomass estimation stratum *i*
Source of data	GIS or/and GPS
Description of measurement methods and procedures to be applied	Areas in project area will be tracked in the field using the GPS. All the project area is considered potential area of shrub biomass.
Frequency of monitoring/recording	Before the start of the project (planting) and adjusted thereafter every three years since the year of the initial verification
Value applied:	See section 1.9 of this PD including the stratification.
Monitoring equipment	GPS (Garmin), GPS Smartphones and GIS.
QA/QC procedures to be applied	Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible; all field team members are trained in GPS/GIS application
Purpose of data	Calculation of project emissions/removals
Calculation method	GIS tool
Comments	-

Data / Parameter	w_i
Data unit	Dimensionless
Description	Ratio of the area of stratum *i* to the sum of areas of tree biomass estimation strata.
Source of data	Calculated
Description of measurement methods and procedures to be applied	N/A
Frequency of	Calculated for each monitoring event, at least every five years

monitoring/recording	
Value applied:	See ex-ante w_i in section 4.3. of this PD.
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions/removals
Calculation method	Area of the stratum *i* divided by the project area
Comments	-

Data / Parameter	n_i
Data unit	Dimensionless
Description	Number of sample plots in stratum *i*
Source of data	Calculated
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	n_i is calculated for each monitoring event, at least every five years
Value applied:	See ex-ante *n* in section 4.3. of this PD.
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions/removals
Calculation method	The calculation method is described in the tool "Calculation of the number of sample plots for measurements within A/R CDM project activities" (version 02.1.0)[13]
Comments	-

Data / Parameter	s_i
Data unit	t d.m. (or t d.m. ha^{-1})
Description	Estimated standard deviation of biomass stock in stratum i
Source of data	Pre-sampling or default value
Description of measurement methods	N/A

[13] Annex 15 of the Executive Board report at its 58th meeting.

and procedures to be applied	
Frequency of monitoring/recording	s_i is calculated for each monitoring event, at least every five years
Value applied:	See ex-ante *n* in section 4.3. of this PD.
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions/removals
Calculation method	Excel or tool available to calculate standard deviation
Comments	-

Data / Parameter	$A_{PLOT,i}$
Data unit	ha
Description	Size of sample plot in stratum *i*
Source of data	Calculated
Description of measurement methods and procedures to be applied	After calculating the number of sample plots required to achieve the desired precision level (90/10) a stratified random selection is carried out. Three different plot sizes have been considered for the first monitoring of the first project activity instance: Forest plantations and AFS: circular plot r = 8 m. Orchards: circular plot r = 15 m. Rubber plantations: rectangular, 3 rows and 6 planting holes per row
Frequency of monitoring/recording	$A_{PLOT,i}$ is calculated for each monitoring event, at least every five years
Value applied:	Forest plantations and AFS: 0.020106 ha, circular plot r = 8 m. Orchards: 0.070686 ha, circular plot r = 15 m. Rubber plantations:0.03528 ha, rectangular plots
Monitoring equipment	N/A
QA/QC procedures to be applied	Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible; all field team members are trained in GPS/GIS application
Purpose of data	Calculation of project emissions/removals
Calculation method	$A_{PLOT,i}$ will be calculated depending on the expected density (trees/ha) in each stratum, with the objective of having from 15 to 20 trees per sample plot.
Comments	-

Data / Parameter	X_i
Data unit	Variable
Description	Variables measured per tree for the calculation of above-ground biomass an allometric equation for species
Source of data	Measured
Description of measurement methods and procedures to be applied	Depending on the variable
Frequency of monitoring/recording	Measured every monitoring event, at least every five years
Value applied:	N/A
Monitoring equipment	Depending on the variable (tape, calliper, etc.)
QA/QC procedures to be applied	Quality control/quality assurance (QA/QC) procedures prescribed in the SOP are applied. In absence of this, QA/QC procedures under national forest inventory; QA/QC procedures from published handbooks; or from the IPCC GPG LULUCF 2003, are applied
Purpose of data	Calculation of project emissions/removals
Calculation method	N/A
Comments	See section 7 for parameters of the first monitoring of the first project activity instance.

Data / Parameter	T
Data unit	Year
Description	Time period elapsed between two successive estimations of carbon stock in a carbon pool
Source of data	Recorded time
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	N/A
Value applied:	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A

Purpose of data	Calculation of project emissions/removals
Calculation method	N/A
Comments	If the two successive estimations of carbon stock in trees are carried out at different points of time in year t_2 and t_1, (e.g. in the month of April in year t_1 and in the month of September in year t_2), then a fractional value is assigned to *T.* See section 7 for value applied in the first monitoring of the first project activity instance.

Data / Parameter	$CC_{SHRUB,i}$
Data unit	Dimensionless
Description	Crown cover of shrubs planted in the project in project stratum *i* at a given point of time in year *t*
Source of data	Measured
Description of measurement methods and procedures to be applied	In the first monitoring it will be made by a transect beginning from plot center and going towards the North. One of the team members walks 60 steps counting how many steps fall on shrub.
Frequency of monitoring/recording	Measured every monitoring event, at least every five years
Value applied:	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	Quality control/quality assurance (QA/QC) procedures prescribed in the SOP are applied. In absence of this, QA/QC procedures under national forest inventory; QA/QC procedures from published handbooks; or from the IPCC GPG LULUCF 2003, are applied
Purpose of data	Calculation of project emissions/removals
Calculation method	CC will be calculated using Excel
Comments	N/A

Data / Parameter	$A_{BURN,i,t}$
Data unit	ha
Description	Area burnt in stratum i
Source of data	Field measurement, remote sensing measurement or any other spatial information available
Description of measurement methods and procedures to be applied	The area shall be delineated either on the ground using GPS, from georeferenced remote sensing data or from any other spatial information available

Frequency of monitoring/recording	This area is measured whenever forest fire has occurred
Value applied:	N/A
Monitoring equipment	GPS (if applied)
QA/QC procedures to be applied	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the IPCC GPG LULUCF 2003, are applied
Purpose of data	Calculation of project emissions/removals
Calculation method	N/A
Comments	Only used in case wild fires occur.

Data / Parameter	$A_{FMF,t}$
Data unit	ha
Description	Area of land subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year *t*
Source of data	Field measurement, remote sensing measurement or any other spatial information available
Description of measurement methods and procedures to be applied	Standard operating procedures (SOPs) prescribed under national forest inventory are applied. In the absence of these, SOPs from published handbooks, or from the *IPCC GPG LULUCF 2003*, may be applied
Frequency of monitoring/recording	This area is measured whenever fire is used to clear the land of harvest residue prior to replanting of the land
Value applied:	N/A
Monitoring equipment	GPS (if applied)
QA/QC procedures to be applied	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the IPCC GPG LULUCF 2003, are applied
Purpose of data	Calculation of project emissions/removals
Calculation method	N/A
Comments	Only used whenever fire is used to clear the land of harvest residue prior to replanting of the land. Not expected in the first project activity instances.

Data / Parameter	$A_{DISP,t}$
Data unit	ha
Description	Area of land from which agricultural activity is being displaced in year *t*
Source of data	Field measurement.
Description of measurement methods and procedures to be applied	Standard operating procedures (SOPs) prescribed under national forest inventory are applied. In the absence of these, SOPs from published handbooks, or from the *IPCC GPG LULUCF 2003*, may be applied
Frequency of monitoring/recording	At every verification
Value applied:	N/A
Monitoring equipment	GPS
QA/QC procedures to be applied	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the IPCC GPG LULUCF 2003, are applied
Purpose of data	Calculation of leakage
Calculation method	N/A
Comments	Not expected in the first project activity instances.

4.3 Monitoring Plan

Following the selected methodology (AR-ACM0003-Version 02.0) requirements, the monitoring plan provides the necessary guidelines for the collection of all relevant data necessary for:

- Verification that the applicability conditions of the methodology have been met: some applicability conditions of the methodology and of the applied tools have been demonstrated ex-ante (see section 2.2) and some others will be verified in the monitoring of the project boundary and of forest establishment. During the monitoring it will be demonstrated that:

  a) The land subject to the project activity does not fall in wetland category;

  b) Soil disturbance attributable to the ARR project activity does not cover more than 10 % of area

- Verification of changes in carbon stocks in the pools selected: methodology described in the monitoring process described below in the sub-section “Monitoring of net anthropogenic GHG removals”.

- Verification of project emissions and leakage emissions: methodology described in the monitoring process described below in the sub-section “Monitoring of net anthropogenic GHG removals”.

This project is part of the portfolio of the Livelihoods Fund and for the monitoring process it will follow the Monitoring of Livelihoods Projects Series – Operating Procedures. These procedures consist in several guidance documents for all monitoring phases: Mapping and stratifying; Pilot inventory; Field work planning; Field work; etc.

The following subsections contain a summary description of the monitoring plan, further information on specific issues is included in the mentioned Operating Procedures.

STRATIFICATION AND SAMPLING DESIGN

Stratification

Biomass distribution over the project area is not homogeneous; therefore stratification should be carried out to improve the precision of biomass estimation. Different stratifications may be required for the baseline and the project scenarios always looking for higher homogeneity inside each stratum to improve precision.

In the first project activity instance only two strata have been considered in baseline estimations (see section 3.1.).

In the case of actual net GHG removals by sinks the stratification for ex ante estimations is based on the project planting plan and on the type of plantation (see sections 1.9).

Table 20. Stratification of first project activity instance

Planting year	Planting system	Stratum	Area (ha)	Area (%)
2013	Rubber	I	38.90	2%
	Forest plantation	II	63.09	4%
2014	Rubber	III	432.05	25%
	Forest plantation	IV	174.45	10%
2015	Rubber	V	432.43	25%
	Forest plantation	VI	337.18	19%
2013-14-15	Agroforestry systems (AFS)	VII	81.75	5%
2013-14-15	Orchards	VIII	64.48	4%
2016	All	Z[14]	133.26	8%
TOTAL			1,757.59	100%

The ex post stratification will be updated periodically, if necessary, because different events are likely to affect current strata: unexpected disturbances occurring during the crediting period affecting differing impacts on various parts of an originally homogenous stratum; two or more different strata may be similar enough to allow their merging into one stratum; etc.

[14] For the first monitoring, 2016´s plantations were all included in a unique stratum. This stratum will not be monitored following the “Non-decrease” approach described in section 6.4. of the AR CDM Methodological tool: Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities. Version 04.2. Carbon stock in this stratum is expected to be low due to the short age of the planted trees.

Sampling procedure

Carbon sampling will take place within the stratified project area. The project will use temporary or permanent sample plots to monitor carbon stock changes in different carbon pools. The number of sample plots will be calculated to reach the targeted precision level of ±10% of the mean of the measured variables at the 90% confidence level in a cost-effective manner, using the last version of the CDM A/R Methodological Tool "Calculation of the number of sample plots for measurements within A/R CDM project activities".

Ex-ante, the number of plots needed in each stratum will be estimated using the A/R Methodological Tool "Calculation of the number of sample plots for measurements within A/R CDM project activities" (Version 02.1.0). According to the tool the number of sample plots will be calculated iteratively. In the first iteration, the number of sample plots for the project area will be calculated applying equation 1 of this tool:

$$n = \frac{N \times {t_{val}}^2 \times (\sum_i w_i \times s_i)^2}{N \times E^2 + {t_{val}}^2 \times \sum_i w_i \times {s_i}^2}$$

Where:

n = Number of sample plots required for estimation of biomass stocks within the project boundary; dimensionless

N = Total number of possible sample plots within the project boundary (i.e. the sampling space or the population); dimensionless

t_{val} = Two-sided Student's t-value at infinite degrees of freedom for the required confidence level; dimensionless

E = Acceptable margin of error (i.e. one-half the confidence interval) in estimation of biomass stock within the project boundary; t d.m. (or t d.m. ha^{-1})

w_i = Relative weight of the area of stratum *i* (i.e. the area of the stratum *i* divided by the project area); dimensionless

s_i = Estimated standard deviation of biomass stock in stratum *i;* t d.m. (or t d.m. ha^{-1})

If the number of sample plots *n* calculated in the first iteration using equation 1 is less than 30, then equation 1 is applied in the second iteration using the *t*-value for degrees of freedom equal to (*n*-1). The value of *n* obtained in the second iteration is the final value of *n*. If the number calculated in the first iteration is 30 or more, then no further iteration is carried out

Based on the tool, when the area sampled is expected to be less than 5% of the project area, the following simplified equation has to been used for estimating the number of sample plots:

$$n = \left({t_{val}}/{E}\right)^2 \times (\sum w_i \times s_i)^2$$ (Equation 2 of the tool)

Where:

n = Number of sample plots required for estimation of biomass stocks within the project boundary; dimensionless

t_{val} = Two-sided Student's t-value at infinite degrees of freedom for the required confidence level; dimensionless

E = Acceptable margin of error (i.e. one-half the confidence interval) in estimation of biomass stock within the project boundary; t d.m. (or t d.m. ha^{-1})

w_i = Relative weight of the area of stratum *i* (i.e. the area of the stratum *i* divided by the project area); dimensionless

s_i = Estimated standard deviation of biomass stock in stratum *i*; t d.m. (or t d.m. ha^{-1})

Before each monitoring, a pre-monitoring will be conducted to obtain the necessary parameters to use the tool (such as the mean and standard deviation of total carbon stock for each stratum).

In the case of the first monitoring not pilot inventory has been done to estimate the parameters necessary to calculate the number of sample plots, as an alternative expert opinion has been considered. Discount rates indicated in Appendix 2 of AR-TOOL 14 will be considered if the sampling error is higher than expected.

The following table shows the number of sample plots designed per stratum.

Table 21. Number of sample plots per stratum used in the first instance monitoring

Planting year	Planting system	Stratum	Area (ha)	wi	ni
2013	Rubber	I	38.90	**0.02**	**11**
	Forest plantation	II	63.09	**0.04**	**12**
2014	Rubber	III	432.05	**0.27**	**30**
	Forest plantation	IV	174.45	**0.11**	**17**
2015	Rubber	V	432.43	**0.27**	**25**
	Forest plantation	VI	337.18	**0.21**	**33**
2013-14-15	Agroforestry systems (AFS)	VII	81.75	**0.05**	**14**
2013-14-15	Orchards	VIII	64.48	**0.04**	**14**
2016	All	Z[15]	133.26	**-**	**-**
TOTAL			1,757.59	**1.00**	**156**

Thus, when the uncertainty in the estimated mean value of a parameter is more than 10 %, the estimated mean value is either increased or decreased by a percentage of the uncertainty. Table 1 in of AR-TOOL 14 provides the uncertainty discount factors to be applied for different ranges of uncertainty.

[15] For the first moritoring, 2016´s plantations were all included in a unique stratum. This stratum will not be monitored following the "Non-decrease" approach described in section 6.4. of the AR CD Methologolical tool: Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities. Version 04.2. Carbon stock in this stratum is expected to be low due to the short age of the planted trees.

Table 22. Uncertainty discount factors

Uncertainty	Discount (% of U)
U ≤ 10%	0%
10% < U ≤ 15%	25%
15% < U ≤ 20%	50%
200% < U ≤ 25%	75%
U > 30%	100%

MONITORING OF NET ANTHROPOGENIC GHG REMOVALS

Ex post estimation of the baseline net GHG removals by sinks

The baseline net GHG removals by sinks are estimated following AR-TOOL14. Baseline net GHG removals by sinks will not be monitored during the crediting period.

Ex post estimation of the actual net GHG removals by sinks

The project participants will put in place a unit dedicated to the monitoring processes. This unit will benefit from the expertise of a forest carbon specialist who will be in charge of the design and calculations of the monitoring. International consultants will support this unit in its initial phase, with the goal of internalizing the right know-how.

Project boundary

The unit will determine any changes in carbon stocks via measuring and monitoring of the project area that has been planted. The size of the project area in each stratum where the project activity has been implemented will be measured in the field using GPS and checked and recorded using GIS tools. This will be performed once previous to the first verification. In following monitoring processes any changes in project boundary will be accounted in all calculations of actual net GHG removals by sinks.

Forest establishment

Forest establishment will be monitored, reporting the verification that plantation has been performed.

This activity will be monitored once after the plantation period and recorded in a database (during the first 2 years).

Estimation of actual net GHG removals

- Changes in carbon stocks in tree and shrub biomass: once the project area is stratified and the sampling design is accomplished, ex-post changes in carbon stocks in tree and shrub biomass will be estimated according to AR-TOOL14. In the estimation of tree biomass it would be necessary to find species-specific volume or allometric equations or develop own ones. When using volume or allometric equations for the estimation of biomass stock and stock change, it would be necessary to measure in all trees included inside the designed sampling plots the variables required by the selected equation. Usually these variables area diameter at breast height (DBH) and total tree height (H). DBH should be measured with a calliper, a diameter tape, a measuring tape, or any other technique able to provide an accurate measurement of the variable. In the case of H it is

recommended the use of hypsometer, clinometer and measuring tape, or any other technique able to provide an accurate measurement of the variable. The area of each sample plot is a key factor in biomass inventories, it is recommended to estimate it based on the tree density (the number of trees per sample plot should be around 20 in order to have a good estimation of the mean living biomass per plot).

- Changes in carbon stocks in deadwood will be calculated based on AR-AM0014 and monitoring will be performed based on this tool. When conservative default-factor based method is selected, then no monitoring of data and parameters will be required.
- Changes in carbon stocks in soil organic carbon pools will be done using the default methods proposed in AR-AM00014, therefore no monitoring is needed.
- GHG emissions within the project boundary: the only source of GHG emission considered in the selected methodology is burning of biomass attributable to the project activity and it will be calculated using the A/R CDM Methodological tool: “Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity, (Version 04.0.0)”.

Ex post estimation of leakage

Displacement of agricultural activities will be monitored based on AR-TOOL15.

Ex post estimation of the net anthropogenic GHG removals

The net anthropogenic greenhouse gas removals by sinks will be calculated based on the selected methodology as the actual net greenhouse gas removals by sinks minus the baseline net greenhouse gas removals by sinks minus leakage as appropriate.

QUALITY CONTROL AND QUALITY ASSURANCE (QA/QC) PROCEDURES

A rigid quality control and quality assurance (QA/QC) method involving Standard Operating Procedures will be implemented to ensure: (i) reliability of collection of field measurements, (ii) verification of the methods used to collect field data, (iii) verification of data entry and analysis techniques, (iv) verification of data maintenance and archiving and (v) upgrading of electronic data with technological changes, shall be followed as discussed below.

Procedures to ensure reliable field measurements

Collecting reliable field measurement data is an important step in the quality assurance plan. Those responsible for the measurement work will be trained in all aspects of the field data collection and data analyses. It is good practice to develop Standard Operating Procedures (SOPs) for each step of the field measurements, which should be adhered to at all times. These SOPs describe in detail all steps to be taken of the field measurements (including standard field forms) and contain provisions for documentation for verification purposes so that future field personnel can check past results and repeat the measurements in a consistent way. For biomass monitoring it would be necessary to measure in the inventory sample plots the parameters of trees and shrub required in the selected equations. To secure the quality of the standard operating procedures to be established, they will be elaborated by third party experts. To ensure the collection and maintenance of reliable field data:

- Field-team members will be fully aware of all procedures and the importance of collecting data as accurately as possible;
- New staff will be adequately trained; and
- Field teams will install test plots if needed in the field and measure all pertinent components using the SOPs to estimate measurement errors.

Procedures to verify field data collection

To verify that sample plots have been installed and the measurements taken correctly, a re-measurement of a percentage (e.g. 10%) of the plots by different crew members from the original field crews will be performed at the end of the fieldwork. Key data points to be re-measured are: location and size of sample plots, number of trees per plot and tree's variables (e.g. DBH, and heights). The verifying crew will be experienced in forest measurement and highly attentive to details. Field data collected at this stage will be compared with the original data. Any errors found will be corrected and recorded. Any errors discovered will be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error.

Procedures to verify data entry and analysis

The field data will be collected using field sheets, and entered into the data analysis software, where they will be checked for accuracy. Possible errors in this process will be minimized by cross-checking the entry of field data, and where necessary, incorporating internal tests into the spreadsheets to ensure that these data are realistic. Communication between all personnel involved in measuring and analyzing data will be used to resolve any apparent anomalies before the final analysis of the monitoring data is completed. If there are any problems with the monitoring plot data that cannot be resolved, the plot will not be used in the analysis.

In an additional check, another independent person will enter data from a percentage (e.g. 10%) of the field sheets into the data analysis software. These two data sets can then be compared to check for errors. Any errors detected will be corrected in the master file. If the calculated measurement error is greater than a defined percentage (e.g. 10%), then all data will be re-entered.

Data maintenance and storage

Because of the relatively long-term nature of these project activities, data archiving (maintenance and storage) will be an important component of the work. Data archiving should take on several forms and also, copies of all data should be provided to each project participant.

Copies (electronic and/or paper) of all field data, data analyses and models, estimates of the changes in carbon stocks and corresponding calculations and models used, any GIS products, as well as copies of the measuring and monitoring reports, should all be stored in a dedicated and safe place, preferably offsite. Given the time frame over which the project activity will take place and the pace of production of updated versions of software and new hardware for storing data, it is recommended that the electronic copies of the data and report be updated periodically or converted to a format that could be accessed by any future software application. All data collected as part of monitoring should be archived electronically and be kept at least for two years after the end of the last crediting period of the project activity.

OPERATIONAL AND MANAGEMENT STRUCTURE

A Monitoring Unit staffed with well-trained members will conduct monitoring (field survey, data collection, QA/QC, GHG removals, etc.). The Monitoring Unit will have the following structure:

- Monitoring teams: in charge of field measurements and data collection in field forms and digital databases. It is expected that each team will be formed at least by 2 people, one in charge of measurements and other in charge of data collection. These teams will be coordinated by the implementing partner (FUNDAECO in the case of the first activity instances).
- Coordination: in charge of the coordination of the monitoring teams and interface with the person in charge of quality and data analysis. This coordinator, from the implementing partner, will be responsible of team training, data quality, data treatment and storage, and technical and logistics management.
- Forest carbon expert: in charge of GHG removals and QC/QA calculations.

A series of manuals will be specifically designed for the project monitoring to ensure the quality of the field work. Data will be processed and calculated in accordance with the applied methodology. The monitoring report will be elaborated by the Monitoring Unit and will be sent to the VVB for verification.

5 ENVIRONMENTAL IMPACT

On June 20, 2016 the Environmental Diagnosis of the project was approved by the Department of Environmental Management and Natural Resources, Ministry of Environment and Natural Resources of Guatemala. Main impacts detected in the diagnostic document are described in the table below.

Moreover, an Environmental Impact Assessment was presented by FUNDAECO to the Department of Environmental Management and Natural Resources on March 15, 2016 and is currently under revision by this institution (both mentioned documents are available for the VVB on request).

Table 23. Environmental impacts

Environmental and social resources	Environmental impact	Type	Level of impact
AIR	Contamination by bad odours	Negative	COMPATIBLE
CLIMATE	Slightest movement of air masses in the future.	Positive	MEDIUM
	Favourable changes in the area microclime.	Positive	MEDIUM
WATER	Surface water contamination by inert (Solids)	Negative	MODERATE
	Pollution of surface water by biodegradable substances.	Negative	MODERATE
	Pollution of surface waters by toxic substances.	Negative	MODERATE
	Increase in surface flows.	Negative	MODERATE

Environmental and social resources	Environmental impact	Type	Level of impact
	Reduction of surface flows.	Positive	MEDIUM
	Reduction of pollution of surface water by inert (Solids).	Positive	MEDIUM
	Reduction of pollution of surface water by biodegradable substances.	Positive	MEDIUM
SOILS	Activation of erosive processes.	Negative	SEVERE
	Destabilization of slopes.	Negative	MODERATE
	Deterioration of surface drainage pattern.	Negative	SEVERE
	Reduction of erosive processes.	Positive	MEDIUM
	Greater stabilization of soils.	Positive	MEDIUM
	Improving the chemical properties of soils.	Positive	MEDIUM
VEGETATION	Deterioration in the composition and structure of vegetation.	Negative	MODERATE
	Improving the plant composition.	Positive	HIGH
	Preservation of plant composition.	Positive	HIGH
FAUNA	Reduction of animal populations.	Negative	MODERATE
LANDSCAPE	Temporary deterioration in the quality of the landscape.	Negative	MODERATE
	Improving the quality of the landscape.	Positive	MEDIUM
	Maintaining the quality of the landscape.	Positive	MEDIUM
SOCIAL	Employment generation.	Positive	MEDIUM
	Improving income levels.	Positive	MEDIUM
SOLID WASTES	Increasing solid waste from plants.	Negative	MODERATE

Regarding specifically to rubber plantations in small plots, one of the key points discussed during the implementation of the project. Finally it was not considered, from the legal point of view, as an impediment to the project implementation because this species is considered by CONAP (2011) as a "naturalized" plant in the exotic species legal framework "*Reglamento de Especies Exóticas e Invasoras*".

As a conclusion of both documents (Environmental Diagnosis and Environmental Impact Assessment), the project activity does not have significant negative impacts affecting natural resources and communities. The only severe negative impacts are temporal impacts during site preparation activities. Because of type of project (ARR activity on degraded lands) the expected impacts in the medium and long term are positive for the restoration of ecosystems and improve of local people livelihoods.

The positive impacts expected as a result of the project are:

- Promote carbon sequestration.
- Generate sustainable incomes for farmers.

- Support recovery of vegetation cover.
- Promote ecological connectivity at the landscape scale.
- Recover watersheds.
- Reduce erosion by runoff.

The FUNDAECO organization will be the environmental enforcer responsible for the implementation of the mitigation measures proposed in the Environmental Management Plan. This plan is designed to prevent, minimize, mitigate and compensate current and potential impacts arising from the establishment of rubber plantations, forest plantations and agroforestry systems.

Even it has not been identified as a socioeconomic impact in the EIA, during stakeholders consultation there has been some complaints regarding the delay of PINFOR/PINPEP payments and fertilizers delivery.

6 STAKEHOLDER COMMENTS

Stakeholders consultation has been done during the different phases of the project. Local stakeholders are key actors in the implementation of the project as the project area is close to rural communities and as project lands are owned by local farmers and local communities. Consultation was done mainly during the following phases of the project:

- Awareness campaign: local people interested in the project are identified and are encouraged to participate and ask questions
- Environmental impact assessment and environmental diagnosis: environmental and socioeconomic impacts of the project have been identified considering stakeholders opinions
- Plantation audit and monitoring: after each plantation campaign a plantation audit was performed visiting a random selection of parcels with local stakeholders. Also during the field monitoring of the first verification period local owners have participated accompanying the field work. During these activities local stakeholders have commented the project

The main conclusion of consultations is that people were motivated by the project and that they perceived future benefits from the ARR activity. Direct and tangible benefits of the project (wood production, coffee production,…) are better perceived by local people that indirect benefits (ecosystem restoration, erosion reduction, …).

7 ACHIEVED GHG EMISSION REDUCTIONS AND REMOVALS

7.1 Data and Parameters Monitored

Table 24. Data and parameters monitored

Data / Parameter	A_i
Data unit	Ha
Description	Area of tree biomass estimation stratum *i*
Value applied:	See section 1.9 of this PD including the stratification.
Comments	-

Data / Parameter	$A_{SHRUB,i}$
Data unit	Ha
Description	Area of shrub biomass estimation stratum *i*
Value applied:	See section 1.9 of this PD including the stratification.
Comments	Same strata for tree and shrub biomass have been considered

Data / Parameter	w_i
Data unit	Dimensionless
Description	Ratio of the area of stratum *i* to the sum of areas of tree biomass estimation strata.
Value applied:	See ex-ante w_i in section 4.3. of this PD.
Comments	-

Data / Parameter	$A_{PLOT,i}$
Data unit	Ha
Description	Size of sample plot in stratum *i*
Value applied:	Forest plantations and AFS: 0.020106 ha, circular plot r = 8 m. Orchards: 0.070686 ha, circular plot r = 15 m. Rubber plantations:0.03528 ha, rectangular plots
Comments	

Data / Parameter	*T*
Data unit	Year
Description	Time period elapsed between two successive estimations of carbon stock in a carbon pool
Value applied:	2.9
Comments	Between 26th August 2013 and 19th July 2016

Data / Parameter	$CC_{SHRUB,i}$
Data unit	Dimensionless
Description	Crown cover of shrubs planted in the project in project stratum *i* at a given point of time in year *t*
Value applied:	Depending on the strata (see details in the Excel file: Field data and calculations)
Comments	

Data / Parameter	$A_{BURN,i,t}$
Data unit	Ha
Description	Area burnt in stratum i
Value applied:	0
Comments	No wild fires have occurred.

Data / Parameter	$A_{FMF,t}$
Data unit	Ha
Description	Area of land subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year *t*
Value applied:	*N/A*
Comments	Only used whenever fire is used to clear the land of harvest residue prior to replanting of the land

Data / Parameter	$A_{DISP,t}$
Data unit	ha
Description	Area of land from which agricultural activity is being displaced in year *t*
Value applied:	*N/A*
Comments	*Activity displacement has not occurred*

Data / Parameter	*TREE_HEIGHT*
Data unit	m (two decimals)
Description	Height of trees in sample plots.
Value applied:	See details in the Excel file: Field data and calculations
Comments	The height has been measured with tape measure or calibrate pole in meters to two decimal places (eg 2.37 m). The measurement is taken from the base to the apex of the main stem. If more than 10 degrees inclined, height has been measured following the inclination of the main stem.

Data / Parameter	D_{30}
Data unit	cm
Description	Diameter of trees planted at 0.30m height
Value applied:	See details in the Excel file: Field data and calculations
Comments	Diameters of trees were measured in centimetres with one decimal (eg 1.3 cm). They were measured with vernier caliper always in the direction perpendicular to the line connecting the center of the plot with the tree.

Data / Parameter	*DBH*
Data unit	cm
Description	Diameter of trees planted at 1.30m height
Value applied:	See details in the Excel file: Field data and calculations
Comments	Diameters of trees were measured in centimeters with one decimal (eg 1.3 cm). They were measured with vernier caliper always in the direction perpendicular to the line connecting the center of the plot with the tree.

7.2 Baseline Emissions

In this project the baseline Net GHG removals by sinks is zero as it is explained in section 3.1.

7.3 Project Emissions

Project emissions of the first verification period of the first project activity instance have been calculated following section 3.2. of this document.

Change in carbon stocks in project - $\Delta C_{P,t}$

Change in carbon stock in tree biomass - $\Delta C_{TREE_PROJ,t}$

Estimation of change in carbon stock in tree biomass (ΔC_{TREE}) have been done following next steps:

Step 1: Fitting specific allometric equations.

Specific equations have been developed in this project for three different groups of species: i) hule, ii) forestry plantation and iii) agroforestry plantation (see table below).

Table 25. Specie groups for the development of the tree allometry

No.	Code	Common name	Scientific name	Species group	Code group
1	Ca	Caoba	*Swietenia macrophylla*	forestry	for
2	Ce	Cedro	*Cedrela odorata*	forestry	for
3	Com	Cola de marrano	*Cojoba Arborea*	forestry	for
4	Cop	Cola de pava	*Cupania guatemalensis*	forestry	for
5	Lab	Laurel Blanco	*Cordia alliodora*	forestry	for
6	Lan	Laurel Negro	*Cordia gerascanthus*	forestry	for
7	Mad	Madrecacao	*Gliricidia sepium*	forestry	for
8	Mat	Matilisguate	*Tabebuia rosea*	forestry	for
9	Mel	Melina	*Gmelina arborea*	forestry	for
10	Pab	Palo Blanco	*Cybistaxdonnell-smithii*	forestry	for
11	Ram	Ramon	*Brosimum alicastrum*	forestry	for
12	Ros	Rosul	*Dalbergia stevensonii*	forestry	for
13	Saj	San Juan	*Vochysia guatemalensis*	forestry	for
14	Sam	Santa Maria	*Calophyllum brasiliense*	forestry	for
15	Tec	Teca	*Tectona grandis*	forestry	for
16	Rat	Rambután		agroforestry	agf
17	Cf	Café		agroforestry	agf
18	Cc	Cacao		agroforestry	agf
19	Car	Cardamomo		agroforestry	agf
20	Pim	Pimienta		agroforestry	agf
21	Li	Limón		agroforestry	agf
22	Mna	Mandarina		agroforestry	agf
23	Nar	Naranja		agroforestry	agf
24	Hu	Hule	Hevea brasiliense	Hule	hu

Power models for stem volume variable were fitted using the Nonlinear Least Squares (nls) function from stats package included in the R software (R Core Team 2013). This function determines the nonlinear (weighted) least-squares estimate of the parameters of a nonlinear model using a Gauss-Newton algorithm. Stem volume has been estimated based on the field measurement of tree height, base tree diameter and diameter at 30 cm, 80 cm, 130 cm and 180 cm.

Table 26. Specific tree allometry developed by the project

Sample size	R^2	RMSE	Range DBH (cm) or/and H (m)	Equation	Code
115	0.8967	0.0254	H < 1.30 m	V=0.078738* D30^1.532569 * H^0.688972	for hu
111	0.9688	0.3734	H > 1.30 m and DBH < 5 cm	V=0.14378* DBH^ 1.91252 * H^0.45610	hu
63	0.7379	0.8372	H > 1.30 m and DBH < 10 cm	V=0.23691*DBH^1.10198*H	for
31	0.9892	0.0175	H < 1.30 m	V=0.06012* D30^1.622765*H	agf
38	0.8978	0.6398	H > 1.30 m and DBH < 10 cm	V=0.2741* DBH^1.10346* H^1.13244	agf

H = Total height; m
DBH = Diameter at breast height; cm
V = Stem volume; dm^3
RMSE = Root Mean Square error; dm^3

Step 2: Selection ofther allometric equations.

In addition, two more allometric equations have been used in the project for the larger trees: i) the Rubber (hule) allometric equation developed in Guatemala by Morales Ralda (2000) and ii) the equation used in the national forest inventory in Guatemala (2002-2003) for broadleaved species.

Table 27. Other tree allometry used in the project

Source	Range DBH (cm) or/and H (m)	Equation	Code
National Forest Inventory of Guatemala 2002-2003	DBH > 10 cm	V = 0,108337266 + 0,000046499 (DBH^2*H)	for agf
Morales Ralda (2000)	DBH > 5 cm	AGB = 0.75*DBH^2	hu

H = Total height; m
DBH = Diameter at breast height; cm
V = Stem volume; m^3
AGB = Above Ground Biomass; Kg

Step 3: Calculation of change in carbon stock in tree biomass

This step is developed in the following sub-steps:

- Sub-step 3.1: Calculation of stem volume per tree (V_{TREE}) per tree ($f_j(x_{1,l},x_{2,l},x_{3,l},...)$) based on the trees variables measured and using the selected allometric equation (see results in *Excel file "Field data and calculations.xlsx"*);

- Sub-step 3.2: Calculation of tree biomass ($B_{TREE,l,j,p,t,i}$) using equation 5 of Appendix 1 of AR-TOOL 14, based on the results of sub-step 2.1. and using the selected default root-shoot equation: ($R_j=e^{(-1.085+0.9256*\ln b)}/b$)) (see results in *Excel file "Field data and calculations.xlsx"*);

- Sub-step 3.3: Calculation of the carbon stock in tree biomass within the project boundary at t_2 ($C_{TREE, t2}$, first monitoring date) and t_1 ($C_{TREE, t1}$, project starting date). As this is the first verification $C_{TREE, t1}$ has been set equal to zero. $C_{TREE, t2}$ is calculated in the Excel file *"Field data and calculations.xlsx"* based on equations of section 3.2 (see summary results in table below);

- Sub-step 3.4: Discount rate application to the calculation of the carbon stock in tree biomass based on monitoring uncertainty. The estimation of the mean carbon stock in tree biomass based on field sampling provides an uncertainty of 21% (calculated using equations 15, 16 and 17 or AR-TOOL14).

Table 28. Summary results in the calculation of $C_{TREE,t2}$

Stratum	Area (ha)	w_i	$b_{TREE,t,i}$ t d.m. ha^{-1}	$b_{TREE,t}$ t d.m. ha^{-1}	$B_{TREE,t}$ t d.m.	$C_{TREE,t2}$ t CO_2-e
2	63.09	0.04	1.35			
1	38.90	0.02	12.45			
4	174.45	0.11	2.21			
3	432.05	0.27	17.50			
6	337.18	0.21	2.65			
5	432.43	0.27	15.55			
8	64.48	0.04	0.33			
7	81.75	0.05	7.20			
TOTAL	**1,624.33**	**1.00**	**-**	**10.31**	**16,740.41**	**28,849.30**

Table 29. Uncertainty of $b_{TREE,t}$

Stratum	Area (ha)	s_i t d.m. ha^{-1}	n_i	$(w_i x s_i)^2/n_i$	
2	63.09	1.98	12	0.00049	
1	38.90	10.62	11	0.00588	
4	174.45	4.41	17	0.01322	
3	432.05	20.13	30	0.95561	
6	337.18	7.40	33	0.07154	
5	432.43	18.95	25	1.01790	
8	64.48	0.63	14	0.00004	
7	81.75	9.11	14	0.01503	**u_c**
TOTAL	**1,624.33**		156	**2.07972**	**0.232**

Based on the results of above tables the conservative value (applying the discount rate) of $C_{TREE,t2}$ has been calculated as **23,839.50 tCO_2-e (28,849.30*(1-0.75*0.232))**. The discount has been applied following Appendix 2 of AR-TOOL14 "Applying uncertainty discount" where is it indicated that for uncertainties between 20% and 30% the discount rate should be 75% of the uncertainty.

As $C_{TREE,t1}$ is zero, then $\Delta C_{TREE} = C_{TREE,t2}$, and $\Delta C_{TREE_PROJ,t} = \Delta C_{TREE} / T = C_{TREE,t2} / T$ = 23,839.50 / 2.9 = **8,220.52 *t CO_2-e.***

Change in carbon stock in shrub biomass - $\Delta C_{SHRUB_PROJ,t}$

Changes in carbon stock in shrub biomass have been calculated using equations of section 3.2. (equations 26 and 27 of AR-TOOL 14). For the use of these equations CC_{SHRUB} has been measured in each sample plot. All calculations are included in the Excel file *"Field data and calculations.xlsx"*, and results are summarized in the following table.

Table 30. Summary results in the calculation of C_{SHRUB}

Planting year/System		Strata	$CC_{SHRUB,i}$	$b_{SHRUB,i}$	$A_{SHRUB,i}$	$b_{SHRUB,i} * A_{SHRUB,i}$		
2013	HULE	1	0.19	7.06	38.90	274.61		
	FORESTAL	2	0.19	7.06	63.09	445.35		
2014	HULE	3	0.11	3.93	432.05	1,697.72		
	FORESTAL	4	0.18	6.51	174.45	1,135.78		
2015	HULE	5	0.20	7.37	432.43	3,187.20		
	FORESTAL	6	0.31	11.47	337.18	3,866.58		
ORCHARDS		8	0.06	8.70	64.48	561.21		
AFS		7	0.23	2.39	81.75	194.98	$C_{SHRUB,t2}$	$\Delta C_{SHRUB_PROJ,t}$
TOTAL						11,363.43	27,416.18	9,453.85

Change in carbon stock in dead wood - $\Delta C_{DW_PROJ,t}$

Following section 3.2. DF_{DW} is 6%, therefore: $C_{DW,i,t2} = C_{TREE,i,t2} * DF_{DW}$ = 23,839.50 t CO_2-e * 6% = **1,430.37 t CO_2-e.** In this first verification $C_{DW,i,t1}$ is considered 0.

In this first verification $\Delta C_{DW_PROJ,t} = dC_{DW(t1,t2)} * 1\ year = (C_{DW,t2} - C_{DW,t1})/T * 1\ year = C_{DW,t2}/T * 1\ year$ = 1,430.37 **/** 2.9 * 1 year = **493.23 t CO_2-e**.

Change in carbon stock in litter – $\Delta C_{LI_PROJ,t}$

Following section 3.2. DF_{LI} is 1%, therefore: $C_{LI,i,t2} = C_{TREE,i,t2} * DF_{LI}$ = 23,839.50 t CO_2-e * 1% = **238.40 t CO_2-e.** In this first verification $C_{DW,i,t1}$ is considered 0.

In this first verification $\Delta C_{LI_PROJ,t} = dC_{LI(t1,t2)} * 1\ year = (C_{LI,t2} - C_{LI,t1})/T * 1\ year = C_{LI,t2}/T * 1\ year$ = 238.40 **/** 2.9 * 1 year = **82.21 t CO_2-e**.

Change in carbon stock in the soil organic carbon (SOC) pool - $\Delta C_{SOC_PROJ,t}$

$\Delta C_{SOC_PROJ,t}$, is calculated using equations and parameters of section 3.2. All calculations are included in the Excel file *"Field data and calculations.xlsx"*, and results are summarized in the following table.

Table 31. Summary results of $\Delta C_{SOC_PROJ,t}$ calculations.

	Time per planting campaign (years)			SOC Annual carbon stock change per planting campaign ($tCO_2e\ yr^{-1}$)			
Project year	**2013/14**	**2014/15**	**2015/16**	**2013/14**	**2014/15**	**2015/16**	**Total**
2013	0.35	0	0	256.74	0.00	0.00	256.74
2014	1	0.66	0	733.53	1,740.31	0.00	2,473.84
2015	1	1	0.62	733.53	2,636.84	1,106.85	4,477.22
2016	0.55	0.55	0.55	403.44	1,450.26	981.88	2,835.58
Total	2.90	2.21	1.17	2,127.24	5,827.41	2,088.73	10,043.38

Increase of non-CO2 GHG emissions within the project boundary - $GHG_{E,t}$

Following the CDM A/R Methodological Tool "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity"[16] and taking into account that there will not be use of fire in site preparation or to clear the land of harvest residue prior to replanting of the land, it has been assumed that $GHG_{E,t}$ is = 0. In the case of forest fires, the only potential source of emissions in this first instance, it has been considered zero in this first verification as indicated in the tool: "For the first verification, emission of non-CO2 GHGs resulting from the loss of trees due to natural or anthropogenic forest fire is assumed to be zero".

Actual net greenhouse gas removals by sinks - $\Delta C_{ACTUAL,t}$

Actual net GHG removals by sink are calculated in an Excel file available to VVB on request (Field data and calculations.xlsx), based on equation $\Delta C_{ACTUAL,t} = \Delta C_{P,t} - GHG_{E,t}$), where $GHG_{E,t}$ = 0 and therefore $\Delta C_{ACTUAL,t} = \Delta C_{P,t}$.

Summary result of $\Delta C_{ACTUAL,t}$ are included in the following table.

Table 32. Actual net GHG removals by sinks

Project year	**$\Delta C_{TREE,t}$ t CO_2-e**	**$\Delta C_{SHRUB,t}$ t CO_2-e**	**$\Delta C_{DW,t}$ t CO_2-e**	**$\Delta C_{LI,t}$ t CO_2-e**	**$\Delta C_{SOC,t}$ t CO_2-e**	**$\Delta C_{PROJ,t}$ t CO_2-e**
2013	2,877.18	3,308.85	172.63	28.77	256.74	6,644.17
2014	8,220.52	9,453.85	493.23	82.21	2,473.84	20,723.65
2015	8,220.52	9,453.85	493.23	82.21	4,477.22	22,727.03
2016	4,521.28	5,199.62	271.28	45.21	2,835.58	12,872.98
TOTAL	**23,839.50**	**27,416.18**	**1,430.37**	**238.40**	**10,043.38**	**62,967.82**

[16] Annex 31 of the Executive Board report at its 65th meeting.

7.4 Leakage

The only leakage emission source considered in the selected methodology is leakage due to the displacement of agricultural activities, and must be calculated using the tool AR-TOOL15[17].

In the project area of the first activity instance, as described in section 3.3., displacement of pre-project agricultural activities is not expected and if it occurs it will be to lands with SOC and biomass stocks equal or lower to the ones in original agriculture lands. Therefore, leakage in the first instance will be set equal to zero ($LK_{,t}$ =0).

7.5 Net GHG Emission Reductions and Removals

Net GHG removals by sinks in the first monitoring period of this first project activity instance are summarized in the following table (calculations are available in the Excel file "Field data and calculations".

Table 33. Net GHG removals by sinks.

Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
2013	0.00	6,644.17	0.00	6,644.17
2014	0.00	20,723.65	0.00	20,723.65
2015	0.00	22,727.03	0.00	22,727.03
2016	0.00	12,872.98	0.00	12,872.98
Total	**0.00**	**62,967.82**	**0.00**	**62,967.82**

The non permanence risk rating is 13% (as determined in the AFOLU non-permanence risk report attached as a separate document). Therefore, the total number of buffer credits that need to be deposited into the AFOLU pooled buffer account is 8,185.

The number of expected GHG credits in this first verification does not exceed the long-term average GHG benefit (See section 3.4): VCUs < Long term average (62,967 - 8,185 = 54,782 < 698.310).

[17] CDM A/R Methodological tool: Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity. Version 02.0
http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-15-v2.0.pdf/history_view