



**Verified Carbon
Standard**

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



Document Prepared by Agresta S. Coop

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

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 implementing partner of this instance has been FUNDAECO, a local NGO, and technologies/procedures described in the PD were the following ones: logistical organization; training and sensitization; land preparation and planting; maintenance; plant protection; access to information and feedback; grievance redress procedures; and conflict prevention and resolution. In the first project activity instance, the afforestation and reforestation of degraded lands in 60 rural communities located in the buffer zone, multiple use zone and zones of influence of the Cerro San Gil Protected Area, Department of Izabal, have been succeeded in using four different planting systems: mixed forest trees plantations, mixed fruit tree family orchards, rubber tree plantations and agroforestry systems. The status of implementation of the project is *established and operational*.

The first instance project area was planted in four years as described in the following table:

Table 1. Planting plan for the first project instance in hectares.

Planting year	Plantation system				
	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

In this second verification 141.68 ha corresponding to 57 properties have been removed from the original project area, representing 8.06% of the original project boundary reported at first verification event. Considering this exclusion, nowadays the project has established plantations on **1.615,91 ha** of degraded and degrading using the four different planting systems.

The number of GHG credits eligible to be issued as VCUs for the first project activity instance of the second monitoring period, as described in section 5.4 of this document, are: **223,415 t CO2-e**.

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
Title	General delegate
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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
Title	Managing Director
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Organization name	Agresta S. Coop.
Role in the Project	Preparation of PD and MR 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 Location

Grouped project

The grouped project Agroforestry and Forest Restoration for Ecological Connectivity, Poverty Reduction and Biodiversity Conservation in Cerro San Gil is located in the Department of Izabal in Guatemala, including all its municipalities: Livingston, Puerto Barrios, Morales, Los Amates and El Estor. Boundaries geodetic coordinates of the initial instance were available in *.kml and *.shp files at the time of submission of the PD to the registry.

The following table summarizes the project boundary of the first instance for the second monitoring period:

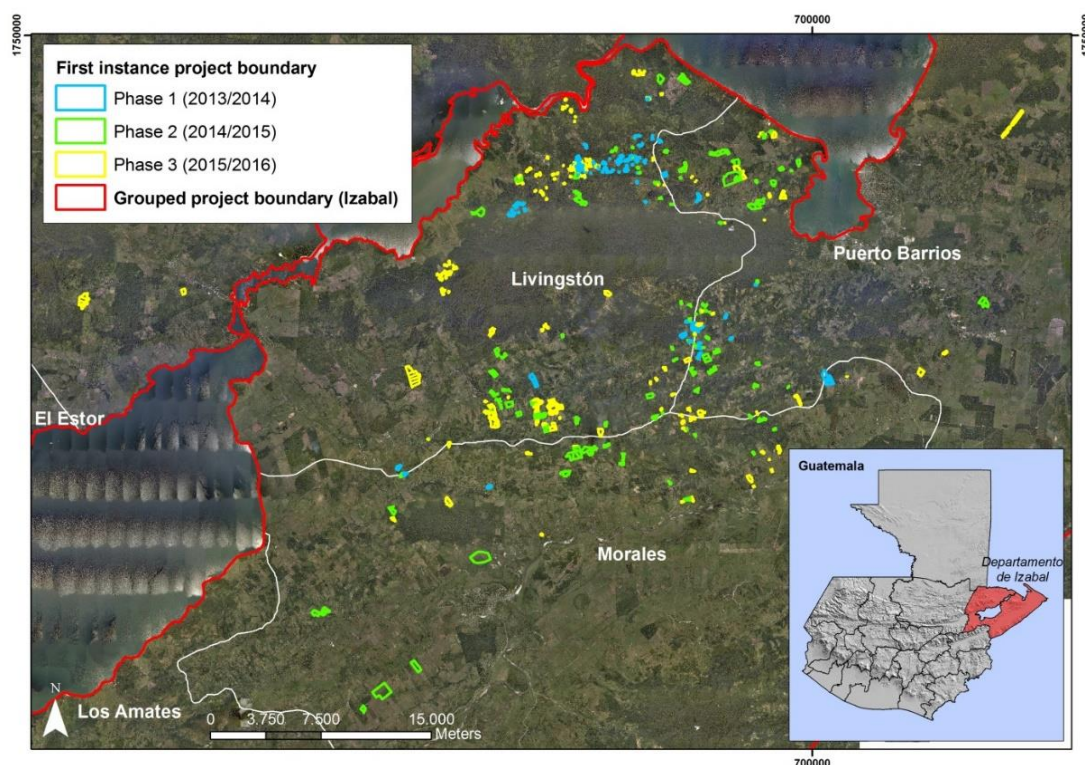
Table 2. Location of the 1st project instance for the second monitoring period.

Municipality	Rural Community	Number of planted parcels	Area (ha)
Livingston	Barra lampara	2	2.76
	Carboneras	1	10.00
	Cayo Quemado	1	21.61
	Creek Maya	78	46.07
	El Paraíso	28	136.61
	La Pintada	1	0.34
	Lámpara	65	70.09
	Las Veguitas	5	15.03
	Los Angeles	6	17.06
	Los Laureles	18	18.59
	Lote 6	5	70.12
	Monte Sión	18	55.59
	Punta de Palma	1	20.17
	Quebrada Seca	17	31.53
	Río Blanco	2	1.93

Municipality	Rural Community	Number of planted parcels	Area (ha)
	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	3	3.60
	Sector A	2	9.62
	Sector B	16	43.62
	Tameja	17	45.48
	Zapotillo	29	21.56
Total, Livingston		324	718.52
Morales	Cerro Azul	3	15.19
	Cimarrón	5	18.26
	Corralitos	1	1.40
	Cucharas	2	5.37
	Cumbre Fría	17	41.38
	El Ciprés	4	28.29
	El Rosario	2	5.00
	El Satélite	4	11.12
	La Pimienta	1	1.90
	Las Jaras	44	69.33
	Los Andes	2	29.99
	Montaña Chiclera	1	4.30
	Naranjito	1	9.65
	Navajoa	2	7.26
	Palestina	12	35.41
	Picuatx	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, Morales		118	532.47
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	6	30.18
	Manacas	1	12.13

Municipality	Rural Community	Number of planted parcels	Area (ha)
	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	4	6.62
	Veracruz	1	4.20
Total, Puerto Barrios		65	364.93
Total, general		507	1.615.91

Figure 1. Location of the planted areas of the 1st Project activity instance in Izabal.



1.8 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:

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

- Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity. Version 04.0.0;
- Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities. Version 03.1 (AR-TOOL12);
- Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities. Version 0.4.2 (AR-TOOL14);
- Tool for estimation of change in carbon stocks in soil organic carbon (SOC) due to the implementation of A/R CDM project activities. Version 01.1.0;
- 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.

1.9 Participation under other GHG Programs

GHG emission removals generated by the Project are not and will not be used for compliance with an emission-trading program or to meet binding limits on GHG emissions. The project is not registered nor is seeking registration under any other GHG programs.

1.10 Other Forms of Credit

GHG emission reductions/removals issued during this Monitoring Report have not been issued as other types of GHG credits or claimed as other forms of environmental credit and are not also used under emission trading programs, other mechanisms that include GHG allowance trading, or as other forms of environmental credit.

1.11 Sustainable Development

This Agroforestry and Forest Restoration for Ecological Connectivity, Poverty Reduction and Biodiversity Conservation project in Cerro San Gil aims to afforest, reforest and restore through different planting systems. The project was implemented in multiple rural communities located in the buffer zone, multiple use zone and zones of influence of the Cerro San Gil Protected Area,

Department of Izabal. These types of ARR projects implemented on degraded lands promote sustainable development of the region, bring benefits to the communities, improve connectivity and/or continuity of forest cover without negative effects on biodiversity at the community and landscape level, and protect existing natural resources.

Therefore, this project is aligned with Guatemala's sustainability policies and contributes to achieving different sustainable development policy objectives established at the national level. The main sustainability policies of Guatemala are the conservation and enhancement of natural heritage, and the conservation of Biological Diversity and Renewable Natural Resources.

Reforestation and restoration of degraded and underutilized land will sequester a significant amount of GHGs compared to the baseline. The project is implemented by the local NGO FUNDAECO, committed to environmental sustainability and social responsibility, based on social communication and participatory management.

Thus, this project is aligned with the sustainability policies of Guatemala and contributes to achieve different nationally stated sustainable development policy objectives. Main sustainability policies of Guatemala are:

- Constitution of the Republic of Guatemala “*Constitución Política de la República de Guatemala*” (Articles 64, 97.126)¹.
- 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 7-2013*” (Articles, 15, 20) ².
- Law for the protection and improvement of the environment “*Ley de protección y mejoramiento del medio ambiente (Decreto 68-1986)*”³.
- Forestry Law “*Ley Forestal, Decreto 101-96*”⁴ (Articles, 6, 8, 46, 98).
- Protected areas Law “*Ley de Áreas Protegidas, Decreto 4-89*”⁵ (Articles, 5, 18, 20, 30, 33, 69).

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*”⁶. This master plan aims to promote the

¹ [Constitución Política de la República de Guatemala](#)

² [Ley Marco para la reducción a la vulnerabilidad, Adaptación obligatoria ante el Cambio Climático y la Mitigación de Gases de Efecto Invernadero, Decreto 7-2013](#)

³ [Ley de protección y mejoramiento del medio ambiente \(Decreto 68-1986\)](#)

⁴ [Ley Forestal, Decreto 101-96](#)

⁵ [Ley de Áreas Protegidas, Decreto 4-89](#)

⁶ [CONAP, FUNDAECO, TNC \(2006\) Plan maestro de la reserva protectora de manantiales Cerro San Gil, Livingston Izabal, documento técnico, Guatemala](#)

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.

In 2015 Guatemala officially adopted the declaration "Transforming our World: The 2030 Agenda for Sustainable Development" that gives life to the 17 Sustainable Development Goals (SDGs), a set of universal goals covering the thematic areas of environmental, economic and social development. The SDG Agenda has also been articulated with the National Development Plan K'atun: Our Guatemala 2032. Thus, Guatemala faithfully integrates the three dimensions of development addressed in the SDG agenda: social, economic and environmental.

This ARR project implemented on degraded lands of multiple rural communities contributes to achieve the following SDGs:



1 No poverty:

The project is carried out on degraded and unproductive land in rural communities. Thanks to the reforestation with rubber, the project participants have a continuous income, which provides them with economic stability. In addition, the planted forestry species provide them with capital that will bring them significant economic benefits in the medium to long term.

Project activities improve soil quality and reduce the risk of landslides due to pre-project soil erosion and degradation. This contributes to target 1.5 by the implementation of local disaster risk reduction strategies.



2 Zero hunger:

This SDG is addressed is addressed through the planting of agroforestry systems with different species mixtures and local orchards that lead to achieving the objective of improving the food security of the communities participating in the project.

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*).

Orchards consist of medicinal plants and food use. Plants grown in orchards include corn (*Zea mays*), beans (*Phaseolus vulgaris*), coconut (*Cocos nucifera*), banana (*Musa sapientum*), mangoes (*Manguifera indica*), yucca (*Manihot sculenta*), malanga (*Colocassia sculenta*), ñame (*Dioscorea alatta*), chico (*Manilkara sapota*), caimito (*Crysobalanus caimito*), sapodilla (*Pouteria zapota*), jocotes (*Spondias* sp.), citrus (*Citrus* spp.), cocoa (*Theobroma cacao*) and papaya (*Carica papaya*), among others.



4 Quality education:

The project contributes to improving both the knowledge of sustainable development and the technical skills of the local communities and the FUNDAECO team. Thanks to this project, they have been able to learn and/or improve their technical skills in reforestation and restoration of degraded lands, as well as the use and commercialization of rubber and other products such as wood products or cardamon.



13 Climate action:

Establishing forestry, agroforestry and orchards plantations on degraded and underutilized lands will sequester significant amount of GHGs compared to baseline. Thus, the project contributes to achieve this SDG, which aims to mitigate the effects of climate change with actions that must also go hand in hand with efforts to integrate disaster risk measures, sustainable natural resource management, and human security.



15 Life on land:

Goal 15 focuses specifically on managing forests sustainably, restoring degraded lands and successfully combating desertification, reducing degraded natural habitats and ending biodiversity loss.

Afforestation, reforestation and restoration of degraded lands through different planting systems carried out in this project aims to improve connectivity and/or continuity of forest cover without negative effects on biodiversity and protect existing natural resources.

2 SAFEGUARDS

2.1 No Net Harm

Possible environmental impacts were identified in the Environmental Impact assessment presented by FUNDAECO to Guatemalan environmental authority, and the PDD indicated as a conclusion that the project activity does not have significant negative impacts affecting natural resources and communities. The only severe impacts were identified to occur during the site preparation activities and were not of concern during this monitoring period as those activities finalized during the previous monitoring period. These impacts were: activation of the erosive processes and deterioration of surface drainage pattern, both caused by the clearing of vegetation in order to increase plat survival. As to reduce this impacts the project promoted the manual cleaning just around the planting point This was a short-term impact affecting only during the first months of planting activity, and that was mitigated as the new plantations are growing proving enough coverage to the soil.

Regarding socio-economic impacts, the Environmental Impact Assessment identifies only positive impacts, as the project plots are located over degraded cropland and degraded grasslands that were not producing benefits to their owners and will turn into productive parcels improving families' livelihoods. Another positive socioeconomic impact is that beneficiaries will have the opportunity to be credited the National Forest Incentive Program granted by the State.

2.2 Local Stakeholder Consultation

As informed in the PDD the project consultation is done through several phases, at the beginning an awareness campaign was implemented to inform about the project and to get local stakeholders' engagement, the awareness campaign consisted of group meetings, radio announcements and individual meetings.

During the monitoring period the project staff-maintained communication and consultation with local stakeholders through group meetings in the case of community plots, and individual meetings or visits in the case of individual owned plots. During this meetings information such as project progress, specific technical recommendations, upcoming phases, and other outstanding subjects were discussed. The project staff prepared meetings reports and/or visit log sheets providing with a copy to the beneficiary. This log sheets registered both information provided by the project technician and inputs, needs and grievances presented by the beneficiaries.

No relevant changes were considered or implemented during this monitoring period. However, some project beneficiaries were not eligible to access to the National Forest Incentive Program, due to the program specific criteria and not the project, even when this is not considered as a

project change and is not under FUNDAECO responsibility, the project staff timely informed to the affected beneficiaries.

No relevant changes have occurred during this monitoring period in relation to relevant laws and regulations covering workers' right in the host country.

Monitoring activities were carried on previous coordination with the project beneficiary, and some of them participated with the field team in measuring and data collection in order to learn about the procedure, but also be engaged into the project result generation. Monitoring Results are presented in a Monitoring brief report that is prepared in Spanish and that is made available in FUNDAECO offices. Once COVID-19 infection risk is reduced, FUNDAECO will organize meetings to present the monitoring report.

Regarding the VVB site visit, a remote site visit was performed. However, a Livelihoods Fund team was visiting the project activities and collaborating in the development of interviews to the local stakeholders. During this process the Community stakeholders were informed in a timely manner and did not raise any questions or complaints.

2.3 AFOLU-Specific Safeguards

According to the section 12.3 of the Environmental Impact Assessment document (provided to the VVB) no negative impacts to local stakeholders were identified. Positive and negative impacts and other 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". In the verification process, interviews were conducted with different Community Stakeholders. These interviews did not reveal any negative social or environmental impacts. Positive impacts were reported, such as continued income from rubber tapping. Therefore, no activities were implemented to mitigate risks local stakeholders due to project implementation.

There are no updates to the property and land use rights of the local stakeholders. Project parcels and boundaries remains the same as in the last monitoring report, and all project beneficiaries are voluntarily participating in the project and hold their legal land titles according to Guatemalan law.

The processes used to communicate and consult with local stakeholders during the monitoring period includes meetings or visits to the project beneficiaries, during these visits project beneficiaries presents doubts and/or complaints, which are registered in the "visit log sheet". Besides the visit sheets, grievances and complaints can be presented trough FUNDAECOs redress procedure (See FUNDAECO Grievance Mechanism). During the monitoring period 3 complaints were registered under this mechanism (See Grievance logbook).

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

The grouped project started with the implementation of the first project activity instance, which was implemented as described in the PD. No new project activities that lead to the intended GHG benefit commenced during the monitoring period.

The implementing partner of this instance was FUNDAECO, a local NGO, and technologies/procedures described in the PD have been followed:

- Logistics organization: organization of teams, headquarters, field bases, means of transport and all the necessary logistics implementation to develop the project.
- Training and awareness: local people awareness and training of FUNDAECO's team have been key issues for the correct implementation of the project. Several activities were designed to motivate local people and make them conscious of the potential positive impacts of forest restoration.
- Site preparation and planting: 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. 20 centimeters wide and 30 centimeters deep holes were made to give to the plants an area for root growth in the first months, allowing better use of nutrients and water absorption. 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 addition, where the mortality is higher than 10% replanting is planned using the same procedure described before.
- Maintenance: maintenance activities are necessary to assure the objective of the project. Maintenance activities have been done by local communities and FUNDAECO since the starting date of the project. During this monitoring period, these activities mainly consisted of:
 - 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.

- Plant protection: Periodic reviews were conducted on the plantation to check the status of the plant, placing special emphasis on cricket, *Hymenoptera*, *Hypsipyla grandella* and rodents.
- Access to Information and Feedback, Grievance Redress Procedures and Conflict Prevention and Resolution: Based on its past experience in the Project Region, FUNDAECO will strengthen and expand its existing procedures to ensure access to information, response to complaints and grievances, and conflict prevention and resolution -from the community to the regional level-. Bases for these Procedures can be founded in the institutional Policy for Gender Equality, No Discrimination and Violation to Fundamental Rights and FUNDAECO Code of Ethics and Values.

Reception, registration, response, resolution and/or referral of grievances will be executed at different geographical and organizational levels, according to their gravity and urgency, ranging from requests of access to information, operational and administrative complaints, grievances and disputes over rights of access, collective conflicts, and potential violations of Legislation and Fundamental Rights.

Different and specific channels of communication and complaint will be used, based on current practices, in order to ensure that all stakeholders, particularly vulnerable populations – such as indigenous women- have rapid access to complaints and grievance redress.

Status of implementation of the project: established and operational. The strategy for achieving emission reductions presented in the Project Description, was consolidated during the second monitoring period project. Overall Non-Permanence Risk Rating from the NPRR remained the same as in the previous monitoring period.

The scope for this second verification includes all the plantations established between 2013 and 2016. It was planned in 2021, starting the field monitoring in April and finishing in July. For the monitoring of the biomass carbon stocks a sampling procedure has been design. Three strata were identified and a total of 200 sample plots have been measured. The second monitoring has been independent from the first one, updating and improving the stratification and the measurement protocol, as described in the SOP. FUNDAECO was in charge of the field measurements with the support of a forest carbon expert for sampling design and calculations.

During this monitoring period, 57 properties have been removed from the original project area. A total of 146.68 ha were excluded. The total area planted in this period, considering the areas that have been removed from the original project area, was **1.615,91 ha**.

Table 3. Actual planting plan for the first project instance in hectares after removing the 57 properties that have left the project and cleared their plantations.

Planting year	Plantation system				
	Rubber	Forest plantation	AFS	Orchards	Total
2013	38.90	61.86	20.49	1.52	122.77
2014	432.05	148.56	21.91	2.86	605.38
2015	432.43	255.63	24.01	59.60	771.66
2016	57.79	52.99	0.86	4.46	116.10
TOTAL	961.17	519.05	67.26	68.43	1,615.91

The total GHG removals generated in this monitoring period, as described in section 5.4 of this document, are: **224,087 t CO₂-e**.

3.2 Deviations

3.2.1 Methodology Deviations

Methodology deviations have not occurred in the second verification period.

3.2.2 Project Description Deviations

In this second verification 141.68 ha corresponding to 57 properties have been removed from the original project area. Even though the reforestation took place in these farms, the owners of these farms were not eligible to access to the National Forest Incentive Program, due to the program specific criteria and not the project. This incentive was considered in the initial structure of the project as part of the co-financing of the plantations. Once the owners did not benefit from this incentive, they decided to abandon the project. Thus, even when this is not under FUNDAECO responsibility and the project staff timely informed to the affected beneficiaries, the owners of these estates left the project and cleared their plantations. Since there is no likelihood of these polygons being reforested and owners coming back to the project there is no point in continuing to monitor and thus these areas have been removed from the project area.

These changes from the validated PD have occurred during this monitoring period. In accordance with the VCS Standard v4.1 Section 3.18 Project Description Deviations, the exclusion exposed previously, does not impact the applicability of the methodology, additionality of the appropriateness of the baseline scenario, and the Project remains in compliance with the applied methodology. The project remains in compliance with the applied methodology.

The deviation affected the total project boundary by reducing 141.68 has, representing 8.06% of the original project boundary reported at first verification event.

In this second verification event an alternative aboveground biomass allometric equation to the stem volume equation included in the PD was used for the larger forestry plantation trees. Table 27 of section 7.3. “Project Emissions” of the PD&MR indicates that the equation used in the

national forest inventory in Guatemala (2002-2003) for broadleaved species is used to estimate stem volume (m^3) of trees in forestry and agroforestry groups with a diameter at breast height larger than 10 cm. Then, a biomass expansion factor is used for conversion of tree stem volume to aboveground tree biomass. In this verification event, the aboveground biomass of these trees was estimated using the allometric equation developed by Arreaga (2002)⁷ for sustainably managed forests in the Maya Biosphere Reserve, Petén, Guatemala. This equation was selected because is used in the Guatemala's Reference Level of Forest Emissions and Removals (FRL) developed for the Emission Reductions Program Document (ER-PD) presented to the Forest Carbon Partnership Facility (FCPF) Carbon Fund.

According to the applied CDM A/R Methodological Tool "Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities", Arreaga (2002) equation also meets the condition of being "derived from a data set of at least 30 sample trees, and the value of coefficient of determination (R^2) was not less than 0.85". The selected equation was developed for species included in the "forestry plantations" group growing specific allometric equation derived from trees growing in edapho-climate conditions similar to those in the project area is considered appropriate, using 139 sample trees and achieved an $R^2=0.95$.

The rest of equations listed in the PD were also used in this second verification. This deviation does only impact the quantification of GHG removals and do not impact the applicability of the methodology, the additionality, or the appropriateness of the baseline scenario.

The long-term average estimations for this monitoring period were conducted using the more updated forest management plan. Contrary to the silvicultural management plan in force during the validation and first monitoring period, all plantation systems are under conservation easements with no intention to harvest after the project crediting period. Only forest plantations system includes in the current management plan partial harvests. Thinnings are planned to be executed every 6 years since year 9 until reaching a planting density of 200-250 trees per hectare. The stand volume removals in each thinning will be 30% of the total. Each plantation system (i.e., rubber, AFS, forest plantation and orchards) growth models were updated considering results of the last monitoring and more realistic and conservative growth rates based on the planted species and local data.

Although the current calculation of the long-term average (1,102,524 t CO₂e) is significantly higher than the previous one (698,310 t CO₂e), the estimation is consistent both with those obtained in this verification and the current forest management plan (see Appendix 1). Change in long-term average estimation is in compliance with the VCS Standard v4.1 Section 3.18 Project Description Deviations, since it does not impact the applicability of the methodology, additionality of the appropriateness of the baseline scenario, and the Project remains in compliance with the applied methodology.

⁷ Arreaga, W. (2002). Almacenamiento del carbono en bosques con manejo forestal sostenible en la Reserva de Biosfera Maya, Petén, Guatemala. [Tesis (M. Sc) -- CATIE, Turrialba (Costa Rica), 2002]. Repositorio Institucional – CATIE, Turrialba (Costa Rica)

3.3 Grouped Projects

The proposed project is a grouped project. The only instance that is subjected to this second verification is described in the project description document. This section is therefore not relevant in the current verification.

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data and parameters available at validation of the grouped project are described in the project description document. The following list includes only data and parameters used in the second verification for the first project activity instance.

Table 4. Data and parameters available at validation.

Data / Parameter	$\Delta C_{BSL,t}$
Data unit	t CO ₂ e
Description	Baseline net GHG removals by sinks in year t
Source of data	N/A
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	Value based on section 5 of AR-TOOL12 as described in section 1.8 of this document
Purpose of Data	Calculation of ex-ante and ex-post baseline emissions
Comments	-

Data / Parameter	$\Delta C_{TREE_PROJ,t_1}$
Data unit	t CO ₂ e
Description	Change in carbon stock in trees within the project boundary in first verification
Source of data	First Monitoring Report
Value applied	23,839.50
Justification of choice of data or description of	Data is used for calculation net GHG emission reductions or removals.

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

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: $R_j = \exp[-1.085 + 0.9256 \cdot \ln(AGB)] / AGB$ Where AGB is the aboveground tree biomass per hectare (t d.m. ha ⁻¹). [Source: Table 4.A.4 of IPCC GPG-LULUCF 2003] 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 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	dm ³

Description	Stem volume of the tree returned by the volume equation for species j relating the measurements of tree / to the stem volume of the tree.	
	Species group	$V_{TREE,j}(x_{1,l}, x_{2,l}, x_{3,l}, \dots)$
	Forest plantation / Rubber	$0.078738 * D_{30}^{1.532569} * H^{0.688972}$
	Rubber	$0.14378 * DBH^{1.91252} * H^{0.45610}$
	Forest plantation	$0.23691 * DBH^{1.10198} * H$
	Agroforestry	$0.06012 * D_{30}^{1.622765} * H$
	Agroforestry	$0.2741 * DBH^{1.10346} * H^{1.13244}$
Source of data	Reforestation and agroforestry in Cerro San Gil, Guatemala.	
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	$f_j(X_{1,l}, X_{2,l}, X_{3,l}, \dots)$	
Data unit	t d.m.	
Description	Above-ground biomass of the tree returned by the allometric equation for species j relating the measurements of tree / to the above-ground biomass of the tree	
	Species group	Equation
	Forest plantation	$f_j(X_{1,l}, X_{2,l}, X_{3,l}, \dots) = 10^{(-4,09992+(2,57782*\text{LOG}_{10}(DBH)))}$
	Rubber	$f_j(X_{1,l}, X_{2,l}, X_{3,l}, \dots) = 0.75*DBH^2$
Source of data	Arreaga, W. (2002). Almacenamiento del carbono en bosques con manejo forestal sostenible en la Reserva de Biosfera Maya, Petén, Guatemala. [Tesis (M. Sc) – CATIE, Turrialba (Costa Rica), 2002]. Repositorio Institucional – CATIE, Turrialba (Costa Rica). Allometric equation developed in Guatemala by Morales Ralda 2000 and PICA 2010.	
Value applied	Result of the application of the equation	
Justification of choice of data or description of		

measurement methods and procedures applied	
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 "LV_FUNDAECO_2021_2 nd _verification_Field_data_GHG_estimations.xlsx")
Value applied	Depending on tree species. (See Excel file "LV_FUNDAECO_2021_2 nd _verification_Field_data_GHG_estimations.xlsx")
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	$BEF_{2,j}$
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 Rubber and Forest plantation 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	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	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	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	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 1600 mm has been selected from the table.
Purpose of Data	Calculation of ex-ante and ex-post project emissions/removals

Comments	-
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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	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 <i>stock change factors</i> 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 6 of 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 <i>stock change factors</i> 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 5. Data and parameters monitored.

Data / Parameter	A_i																						
Data unit	ha																						
Description	Area of tree biomass estimation stratum i																						
Source of data	Ex-post stratification																						
Description of measurement methods and procedures to be applied	Once the criteria for ex-post stratification have been selected the project boundary has been stratified and A_i has been calculated using GIS.																						
Frequency of monitoring/recording	At least for the first monitoring but can be updated in every verification.																						
Value monitored	See section 4.3 of this MR including the stratification. <table> <tr> <th>Stratum</th><th>A_i (ha)</th></tr> <tr> <td>Forestal 0-10</td><td>164.44</td></tr> <tr> <td>Forestal 10-30</td><td>149.30</td></tr> <tr> <td>Forestal 30-100</td><td>203.06</td></tr> <tr> <td>Hule 0-10/2013-14</td><td>374.74</td></tr> <tr> <td>Hule 0-10/2015-16</td><td>387.06</td></tr> <tr> <td>Hule 10-30</td><td>141.64</td></tr> <tr> <td>Hule 30-100</td><td>46.87</td></tr> <tr> <td>SAF</td><td>80.36</td></tr> <tr> <td>Huerto</td><td>68.43</td></tr> <tr> <td>Total</td><td>1,615.91</td></tr> </table>	Stratum	A_i (ha)	Forestal 0-10	164.44	Forestal 10-30	149.30	Forestal 30-100	203.06	Hule 0-10/2013-14	374.74	Hule 0-10/2015-16	387.06	Hule 10-30	141.64	Hule 30-100	46.87	SAF	80.36	Huerto	68.43	Total	1,615.91
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Hule 30-100	46.87																						
SAF	80.36																						
Huerto	68.43																						
Total	1,615.91																						
Monitoring equipment	GIS and other spatial information software																						

QA/QC procedures to be applied	N/A
Purpose of the 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	Ex-post stratification																						
Description of measurement methods and procedures to be applied	Once the criteria for ex-post stratification have been selected the project boundary has been stratified and A_i has been calculated using GIS.																						
Frequency of monitoring/recording	At least for the first monitoring but can be updated in every verification.																						
Value monitored	See section 4.3 of this MR including the stratification. <table> <tr> <th>Stratum</th><th>A_i (ha)</th></tr> <tr> <td>Forestal 0-10</td><td>164.44</td></tr> <tr> <td>Forestal 10-30</td><td>149.30</td></tr> <tr> <td>Forestal 30-100</td><td>203.06</td></tr> <tr> <td>Hule 0-10/2013-14</td><td>374.74</td></tr> <tr> <td>Hule 0-10/2015-16</td><td>387.06</td></tr> <tr> <td>Hule 10-30</td><td>141.64</td></tr> <tr> <td>Hule 30-100</td><td>46.87</td></tr> <tr> <td>SAF</td><td>80.36</td></tr> <tr> <td>Huerto</td><td>68.43</td></tr> <tr> <td>Total</td><td>1,615.91</td></tr> </table>	Stratum	A_i (ha)	Forestal 0-10	164.44	Forestal 10-30	149.30	Forestal 30-100	203.06	Hule 0-10/2013-14	374.74	Hule 0-10/2015-16	387.06	Hule 10-30	141.64	Hule 30-100	46.87	SAF	80.36	Huerto	68.43	Total	1,615.91
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Hule 10-30	141.64																						
Hule 30-100	46.87																						
SAF	80.36																						
Huerto	68.43																						
Total	1,615.91																						
Monitoring equipment	GIS																						
QA/QC procedures to be applied	N/A																						
Purpose of the data	Calculation of project emissions/removals																						
Calculation method	GIS tool																						
Comments	-																						

Data / Parameter	n_i
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Data unit	Dimensionless			
Description	Number of sample plots in stratum <i>i</i>			
Source of data	Calculated			
Description of measurement methods and procedures to be applied	N/A			
Frequency of monitoring/recording	<i>n_i</i> is calculated for each monitoring event, at least every five years			
Value monitored		Stratum	<i>A_i</i> (ha)	<i>n_i</i>
		Forestal 0-10	164.44	15
		Forestal 10-30	149.30	14
		Forestal 30-100	203.06	10
		Hule 0-10/2013-14	374.74	50
		Hule 0-10/2015-16	387.06	52
		Hule 10-30	141.64	19
		Hule 30-100	46.87	10
		SAF	80.36	17
		Huerto	68.43	13
		Total	1,615.91	200
Monitoring equipment	N/A			
QA/QC procedures to be applied	N/A			
Purpose of the 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) ⁸			
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	After calculating the number of sample plots required to achieve the desired precision level (90/10) a stratified random selection is carried

⁸ Annex 15 of the Executive Board report at its 58th meeting.

and procedures to be applied	out. Three different plot sizes have been considered for the second monitoring of the first project activity instance: Forest plantations and AFS: circular plot $r = 8$ m. Orchards: circular plot $r = 15$ m. Rubber plantations: circular plots $r = 11$ m.
Frequency of monitoring/recording	$A_{PLOT,i}$ is calculated for each monitoring event, at least every five years
Value monitored	Forest plantations and AFS: 0.020106 ha, circular plots $r = 8$ m. Orchards: 0.070686 ha, circular plots $r = 15$ m. Rubber plantations: 0.038146 ha, circular plots $r = 11$ m.
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 the data	Calculation of project emissions/removals
Calculation method	$A_{PLOT,i}$ was 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	<i>DBH</i>
Data unit	cm
Description	Stem diameter at 1.3 m per tree within sample plots for the estimation of aboveground biomass
Source of data	Measured
Description of measurement methods and procedures to be applied	Measurement of the variable in all trees inside the sample plot.
Frequency of monitoring/recording	Measured every monitoring event, at least every five years
Value monitored	See LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx
Monitoring equipment	Calliper or tape
QA/QC procedures to be applied	Use SOP for sample plots described in Monitoring plan. Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible.
Purpose of the data	Calculation of project emissions/removals
Calculation method	Not applicable

Comments	-
Data / Parameter	D_{30}
Data unit	cm
Description	Stem diameter at 0.3 m per tree within sample plots for the estimation of aboveground biomass
Source of data	Measured
Description of measurement methods and procedures to be applied	Measurement of the variable in all trees inside the sample plot.
Frequency of monitoring/recording	Measured every monitoring event, at least every five years
Value monitored	See LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx
Monitoring equipment	Calliper or tape
QA/QC procedures to be applied	Use SOP for sample plots described in Monitoring plan. Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible.
Purpose of the data	Calculation of project emissions/removals
Calculation method	Not applicable
Comments	-

Data / Parameter	H
Data unit	m
Description	Height per tree within sample plots for the estimation of aboveground biomass
Source of data	Measured
Description of measurement methods and procedures to be applied	Measurement of the variable in all trees inside the sample plot using tape.
Frequency of monitoring/recording	Measured every monitoring event, at least every five years
Value monitored	See Excel file LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx
Monitoring equipment	Tape, graduated pole and Suunto hypsometer (graduated in meters with a precision of 0.25 m; no calibration is required)

QA/QC procedures to be applied	Use SOP for sample plots described in Monitoring plan. Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible.
Purpose of the data	Calculation of project emissions/removals
Calculation method	Not applicable
Comments	-

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 monitored	4,95
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of the 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 .

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 this monitoring it will be made by a transect beginning from plot center and going towards the center of the planting area. 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 monitored	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 <i>IPCC GPG LULUCF 2003</i> , are applied
Purpose of the data	Calculation of project emissions/removals
Calculation method	CC will be calculated using Excel
Comments	N/A

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	Measured
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 <i>IPCC GPG LULUCF 2003</i> , may be applied
Frequency of monitoring/recording	At every verification
Value monitored	N/A
Monitoring equipment	GPS / GIS
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 <i>IPCC GPG LULUCF 2003</i> , are applied
Purpose of the data	Calculation of leakage
Calculation method	N/A
Comments	Activity displacement did not 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	Measured

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 <i>IPCC GPG LULUCF 2003</i> , 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 monitored	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 <i>IPCC GPG LULUCF 2003</i> , are applied
Purpose of the 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

Data / Parameter	$A_{BURN,i,t}$
Data unit	ha
Description	Area burnt in stratum i 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	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 monitored	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 <i>IPCC GPG LULUCF 2003</i> , are applied
Purpose of the data	Calculation of project emissions/removals
Calculation method	N/A
Comments	Only used in case wildfires occur.

4.3 Monitoring Plan

This project is part of the portfolio of the Livelihoods Fund and for the monitoring process has followed the Monitoring of Livelihoods Projects Series –Operating Procedures. These procedures consist of several guidance documents for all monitoring phases: Mapping and stratifying; Pilot inventory; Field work planning; Field work; etc. (See SOP document).

The following subsections contain a summary description of the monitoring plan, further information on specific issues is included in the SOP developed for this second verification based on the mentioned Operating Procedures.

PROJECT BOUNDARY MONITORING

The monitoring of the project boundary was done, as described in the following list, during the first verification period. The unit determined 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 plantation parcel where the project activity has been implemented was measured in the field using GPS and checked and recorded using GIS tools.

STRATIFICATION AND SAMPLING DESIGN

Stratification

In the first monitoring of the project the area was stratified in nine strata based on the project planting plan and on the type of plantation (see sections 1.9 of the PD). As a result of this stratification the uncertainty obtained in the estimation of tree biomass was higher than the 20%. Even tree age and ecological condition may be good parameters to get homogenous strata, in terms of biomass stocks, tree mortality and variation in plant growth in the different properties caused the tree biomass to be not very uniform within the strata.

Thus, for this second verification, a new project stratification was performed. As in previous verification, the stratification included plantation system as a main criterion. However, tree mortality for rubber and forest species plantations was adopted as a new parameter for stratification. Tree mortality was determined in terms of canopy cover by field observations and visualization on satellite images. Plantation campaign was also considered in the case of rubber plantations.

Thus, a total of nine strata were defined as shown in the following table:

Table 6. Stratification of the project area.

Stratum	Planting system	Mortality (% of property surface)	Planting year	A _i (ha)
Forest 0-10	Forest plantation	0-10	-	164.44
Forest 10-30	Forest plantation	10-30	-	149.30
Forest 30-100	Forest plantation	30-100	-	203.06
Rubber 0-10/2013-14	Rubber	0-10	2013-14	374.74
Rubber 0-10/2015-16	Rubber	0-10	2015-16	387.06
Rubber 10-30	Rubber	10-30	-	141.64
Rubber 30-100	Rubber	30-100	-	46.87
AFS	Agroforestry systems (AFS)	-	-	80.36
Orchards	Orchards	-	-	68.43
Total				1,615.91

Sampling design/sampling procedure

The following paragraphs summarize the sampling procedure described in the SOP. Carbon sampling took place within the stratified project area using temporary sample plots to monitor carbon stock changes in different carbon pools.

Characteristics of sample plots:

Three different plot sizes have been considered for the second monitoring of the first project activity instance:

- Forest plantations and AFS: circular plot $r = 8$ m (201.1 m²). The proposed plot size aims to achieve a sample of 15 to 20 trees within each plot.
- Rubber plantations: circular plot $r = 11$ m (380.1 m²). Planting spacing in the strata including this planting system is not square but 7 m x 2.8 m or 6 m x 3 m. Thus, the proposed plot size aims to achieve a sample of 15 to 20 trees within each plot.
- Orchards: circular plot $r = 15$ m (706.9 m²). The bigger size of these plots is due to the variable spacing of this type of plantation, being even up to 7 m x 7 m.

Number of sample plots:

Although no pilot inventory of the project area was carried to obtain the mean and standard deviation of total carbon stock for each stratum, data on previous verification were used to get a good approximation of the number of sample plots needed to achieve the required levels of uncertainty. Due to the heterogeneity of biomass carbon stock in the project area, the total number of necessary sample plots to get a sampling error lower than 10% is too high. As the

measurement of a high number of sample plots was not feasible, the project proponent decided to estimate biomass carbon stocks with a higher uncertainty than 10% and apply an uncertainty discount to the monitoring results following Appendix 2 of AR-TOOL14.

Therefore, based on previous verification data and expert opinion, a total of 200 sample plots were planned in a stratified random sampling. The following table shows the number of sample plots designed per stratum.

Table 7. Number of sample plots per stratum measured.

Stratum	A_i (ha)	w_i	n_i
Forest 0-10	164.44	0.10	15
Forest 10-30	149.30	0.09	14
Forest 30-100	203.06	0.13	10
Rubber 0-10/2013-14	374.74	0.23	50
Rubber 0-10/2015-16	387.06	0.24	52
Rubber 10-30	141.64	0.09	19
Rubber 30-100	46.87	0.03	10
AFS	80.36	0.05	17
Orchards	68.43	0.04	13
Total	1,615.91		200

Plot location:

Plots were randomly located in each stratum, ensuring that the entire area of the plot is within the boundaries of the planting area. Sample plots were located only in accessible areas since there were 274.98 ha corresponding to 29 properties where field monitoring team was not able to access. This situation was due to a lack of understanding between FUNDAECO and the landowners to access these plots after they were declared ineligible for the National Forestry Incentives Fund. Although the owners maintained the management of their plantations, access to the project's technical teams to the plantations was restricted due to the lack of incentives from the Government. The Project's technical team will continue to reach out to these landowners, especially at harvest time, to support them with training and technical assistance activities. Preservation of plantations was verified by visual inspection on high-resolution optical satellite imagery. Therefore, field data were not sampled in any of these areas but were included in the corresponding strata (A_i), since it was assumed that the plantation conditions remained intact. Therefore, carbon stock in these unsampled areas should be equal to the average carbon stock of the sampled areas.

The process followed for the selection of plots (the results of this process are included in * .shp files) is explained below:

1. Determination of accessible properties within each stratum.

2. Estimation of the definitive area per plot. Considering the definitive number of plots per stratum, it was calculated for each case the ha/plot.
3. Guided selection of properties. The surface area of each property was divided by the value obtained per stratum in the previous point, identifying which farms should have sampling plots due to their size and how many plots should be sampled.
4. Sample plots were randomly located within these properties using QGIS.
5. The remaining properties with less than the minimum area were randomly selected stratum 3 using QGIS.
6. Sample plots were randomly located within these properties using QGIS.

Field work:

- *Field work preparation* (field forms, digital maps, GPS with sample plots, measurement equipment, etc.)
- Plot location: with GPS
- *Plot measurement*: center field plot identification.
- *Field data collection*: collection of qualitative and quantitative information of properties and trees within the sample plot (species identification, tree height and diameter, etc). A field form was designed specifically for this monitoring event to collect all the necessary information in each sample plot.
- *Data recording, storage and transfer*: i) field data were taken on the designed field form
ii A person from FUNDAECO was in charge of transferring the information from the paper forms to an Excel file no more frequently than once a week which was saved stored in a cloud storage service.

MONITORING OF NET ANTHROPOGENIC GHG REMOVALS

Ex post estimation of the baseline net GHG removals by sinks

The baseline net GHG removals by sinks were estimated following AR-TOOL14, as indicated in the PD, therefore they have not been monitored.

Ex post estimation of the actual net GHG removals by sinks

The monitoring of the GHG removals has been based on the, above explained, monitoring of the project boundary, the stratification of the project and the sampling design. The project boundary monitoring was done after each plantation campaign at the same time of the monitoring of forest

establishment. During the measurement of each planted polygon, it was confirmed that planting activities were well-implemented and conform to the practice described in the VCS PD.

Ex post estimation of the actual net GHG removals by sinks has been done as explained in the following paragraphs.

- *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 have been estimated according to AR-TOOL14. Five specific volume equations developed for the project and two allometric equations were used to estimate each tree biomass within sample plots. Based on those equations the following variables have been measured:
 - H = Tree height (m), measured for:
 - Forestry plantation species → All trees with $DBH < 10$ cm;
 - Rubber → 4 randomly selected trees with $DBH < 5$ cm (if any); and
 - Orchard and AFS species → All trees.
 - DBH = Diameter at breast height (cm).
- *Changes in carbon stocks in deadwood* were estimated based on A/R CDM 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., and monitoring will be performed based on this tool. A conservative default-factor based method was selected, then no monitoring of data and parameters was required.
- *Changes in carbon stocks in soil organic carbon pools* were estimated using the default methods proposed in the A/R CDM Methodological “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities” (Version 1.1.0) AR-TOOL16 , 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)”. In this grouped project there will not be fire for site preparation or fire to clear the land of harvest residue prior to replanting of the land or other forest management. The only potential source of GHG emission is forest fires that are monitored during the verification period.

Ex post estimation of leakage

In the first project activity instance displacement of pre-project agricultural activities does not occur. No specific data needs to be monitored for the assessment of this source of leakage.

Ex post estimation of the net anthropogenic GHG removals

The net anthropogenic GHG removals by sinks were calculated based on the selected methodology as the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage as appropriate.

QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC) PROCEDURES

A rigid quality assurance and quality control (QA/QC) method involving Standard Operating Procedures was 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.

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 were trained in all aspects of the field data collection and data analyses. A Standard Operating Procedures (SOPs) have been developed including all steps of the field measurements, and this document has been shared with field teams. This SOP describes in detail all steps to be taken of the field measurements (including standard field forms) and contains provisions for documentation for verification purposes so that future field personnel can check past results and repeat the measurements in a consistent way. To secure the quality of the standard operating procedures, they have been elaborated by third party experts, in close collaboration with the implementing partner. To ensure the collection and maintenance of reliable field data:

- Field-team members are fully aware of all procedures and of the importance of collecting data as accurately as possible.
- New staff has been adequately trained.
- Field teams installed 10 test plots and measured all pertinent components using the SOPs to estimate measurement errors.

Procedures to verify field data collection

To verify that sample plots were installed, and the measurements taken correctly, a re-measurement of 10 (5%) of the plots by different crew members from the original field crews was performed at the end of the fieldwork. Key data points re-measured were: location and size of sample plots, number of trees per plot and tree's variables (e.g., *DBH*, and heights). The verifying crew was experienced in forest measurement and highly attentive to details. Field data collected at this stage was compared with the original data. Any errors discovered was expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error. If difference in sample plot biomass between monitoring plots and re-measured plots is higher than 1% but less than 10%, a correction factor equal to the difference shall be applied, by reducing all the original data subtracting the amount of error. If the difference is higher than 10% all monitoring should be repeated.

Procedures to verify data entry and analysis

The field data was collected using field sheets, and entered into the data analysis software, where they will be checked for accuracy. Possible errors in this process should 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 was used to resolve any apparent anomalies before the final analysis of the monitoring data is completed. Where any problems with the monitoring plot data that could not be resolved, the plot was not be used in the analysis.

Any errors detected were corrected in the master file. If the calculated measurement error is greater than a defined percentage (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) is an important component of the work. The data file was saved in various forms, and, in addition, copies of all data were provided to each participant in the project.

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, were 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, the electronic copies of the data and report were updated periodically. All data collected as part of monitoring were archived electronically and will 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 conducted the monitoring (field survey, data collection, QA/QC, GHG removals, etc.). The Monitoring Unit had the following structure:

- Monitoring teams: in charge of field measurements and data collection in field forms and digital databases. Each team was formed by 3-4 people, one in charge of field plot location and measurements transcription to field form, a second one in charge of plot boundaries delineation and visual inspection of qualitative variables, and other or others in charge of tree feature measurements. These teams were coordinated by the implementing partner (FUNDAECO).
- 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, was 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 were specifically designed for the project monitoring to ensure the quality of the field work. Data were processed and calculated in accordance with the applied methodology. The monitoring report was elaborated by the Monitoring Unit and sent to the VVB for verification.

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

In this project, the baseline Net GHG removals by sinks is zero as it is explained below. Following the mentioned methodology, the baseline net GHG removals by sinks have been calculated as follows:

$$\Delta C_{BSL,t} = \Delta C_{TREE_BSL,t} + \Delta C_{SHRUB_BSL,t} + \Delta C_{DW_BSL,t} + \Delta C_{LI_BSL,t} \quad (\text{Equation 1, 1 of AR-ACM0003})$$

Where:

$$\Delta C_{BSL,t} = \text{Baseline net GHG removals by sinks in year } t; t \text{ CO}_2\text{-e}$$

$\Delta C_{TREE_BSL,t}$	= Change in carbon stock in baseline tree biomass within the project boundary in year t, as estimated in AR-TOOL14 ⁹ ; 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 AR-TOOL14; 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 AR-TOOL12 ¹⁰ ; 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 AR-TOOL12 ¹¹ ; t CO ₂ -e

As confirmed in section 2.4 of the PD and confirmed in the project, 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 during the first monitoring period from local farmers 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

⁹ CDM 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
<https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-14-v4.2.pdf>

CDM 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
<https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-12-v3.1.pdf>

CDM 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
<https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-12-v3.1.pdf>

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 than 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 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 biomass - $\Delta C_{DW_BSL,t}$

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.

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.

5.2 Project Emissions

The actual net GHG removals by sinks have been calculated using equation 2 of the methodology, as described below.

$$\Delta C_{ACTUAL,t} = \Delta C_{P,t} - GHG_{E,t} \quad (\text{Equation 2, 2 of AR-ACM0003})$$

Where:

- $\Delta C_{ACTUAL,t}$ = Actual net greenhouse gas removals by sinks at time t; t CO₂-e
- $\Delta C_{P,t}$ = Change in carbon stocks in project, occurring in the selected carbon pools, at time t; t CO₂-e
- $GHG_{E,t}$ = Increase of non-CO₂ GHG emissions within the project boundary as a result of the implementation of the A/R CDM project activity, in year t, t CO₂-e

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

$\Delta C_{P,t}$ is calculated using equation 3 of the methodology:

$$\Delta C_{P,t} = \Delta C_{TREE_PROJ,t} + \Delta C_{SHRUB_PROJ,t} + \Delta C_{DW_PROJ,t} + \Delta C_{LI_PROJ,t} + \Delta C_{SOC_PROJ,t} \quad (\text{Equation 3, 3 of AR-ACM0003})$$

Where:

- $\Delta C_{P,t}$ = Change in carbon stocks in project, occurring in the selected carbon pools, at time t; t CO₂-e
- $\Delta C_{TREE_PROJ,t}$ = 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 CO₂-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 CO₂-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 CO ₂ -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 CO ₂ -e
$\Delta C_{SOC_PROJ,t}$	= Change in carbon stock in the soil organic carbon (SOC) pool within the project boundary, 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 CO ₂ -e

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

$\Delta C_{TREE_PROJ,t}$, in this grouped project, has been calculated using sections 7 and 8 of AR-TOOL14. Specifically, change in carbon stock in trees in a year (annual change) between two successive verifications has been calculated under the assumption of linear change using the equation 11 in AR-TOOL14:

$$\Delta C_{TREE_PROJ,t} = \frac{C_{TREE_PROJ,t_2} - C_{TREE_PROJ,t_1}}{T} \times 1 \text{ year} \quad (\text{Equation 4, 11 of AR-TOOL14})$$

Where:

$\Delta C_{TREE_PROJ,t}$	= Change in carbon stock in trees within the project boundary in year t; t CO ₂ -e
C_{TREE_PROJ,t_2}	= Carbon stock in trees within the project boundary at time t_2 ; t CO ₂ -e
C_{TREE_PROJ,t_1}	= Carbon stock in trees within the project boundary at time t_1 ; t CO ₂ -e
T	= Time elapsed between two successive estimations ($T=t_2 - t_1$); yr

The uncertainty in the estimation of C_{TREE_PROJ,t_1} was 23.2% (calculated using equation 15 of AR-TOOL14). As uncertainty was higher than 10%, the uncertainty discount factors provided by Table 1 in Appendix-2 of AR-TOOL14 were used. Thus, a discount factor 75% of the uncertainty was applied. applied in previous verification event to $\Delta C_{TREE_PROJ,t}$ and not to $C_{TREE_PROJ,t}$. For this reason, and in order to harmonize the value of change in carbon stock in tree biomass with previous verifications, C_{TREE_PROJ,t_1} was defined as:

$$C_{TREE_PROJ,t_1} = \Delta C_{TREE_PROJ,t_1} \quad (\text{Equation 5})$$

Where:

$\Delta C_{TREE_PROJ,t_1}$ = Change in carbon stock in trees within the project boundary in first verification event; t CO₂-e

The next equations are also used:

$$C_{TREE} = \frac{44}{12} \times CF_{TREE} \times B_{TREE} \quad (\text{Equation 6, 12 of AR-TOOL14})$$

$$B_{TREE} = A \times b_{TREE} \quad (\text{Equation 7 13 of AR-TOOL14})$$

$$b_{TREE} = \sum_{i=1}^M w_i \times b_{TREE,i} \quad (\text{Equation 8, 14 of AR-TOOL14})$$

$$U_c = \frac{t_{val} \times \sqrt{\sum_{i=1}^M w_i^2 \times \frac{s_i^2}{n_i}}}{b_{TREE}} \quad (\text{Equation 9, 15 of AR-TOOL14})$$

$$b_{TREE,i} = \frac{\sum_{p=1}^{n_i} b_{TREE,p,i}}{n_i} \quad (\text{Equation 10, 16 of AR-TOOL14})$$

$$b_{TREE,p,i} = \frac{B_{TREE,p,i}}{A_{PLOT,i}} \quad (\text{Equation 11, 1 Appendix 1, AR-TOOL14})$$

$$B_{TREE,p,i} = \sum_j B_{TREE,j,p,i} \quad (\text{Equation 12, 2 Appendix 1, AR-TOOL14})$$

$$B_{TREE,p,i} = \sum_j B_{TREE,l,j,p,i} \quad (\text{Equation 13, 3 Appendix 1, AR-TOOL14})$$

$$B_{TREE,l,j,p,i} = f_j(X_{1,l}, X_{2,l}, X_{3,l}, \dots) \times (1 + R_j) \quad (\text{Equation 14, 4 Appendix 1, AR-TOOL14})$$

$$B_{TREE,l,j,p,i} = V_{TREE,j}(X_{1,l}, X_{2,l}, X_{3,l}, \dots) \times D_j \times BEF_{2,j} \times (1 + R_j) \quad (\text{Equation 15, 5 Appendix 1, AR-TOOL14})$$

Where:

C_{TREE} = Carbon stock in trees in the tree biomass estimation strata; t CO₂-e.

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} = Tree biomass in the tree biomass estimation strata; t d.m.

b_{TREE} = Tree biomass in the tree biomass estimation strata; 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 ($w_i = A_i/A$), dimensionless

U_c	= Uncertainty in C_{TREE}
t_{val}	= Two-sided Student's t-value for a confidence level of 90 per cent and degrees of freedom equal to $n - M$, where n is total number of sample plots within the tree biomass estimation strata and M is the total number of tree biomass estimation strata
$b_{TREE,i}$	= Mean tree biomass per hectare in stratum i ; t d.m. ha ⁻¹
n_i	= Number of sample plots in stratum i
$b_{TREE,p,i}$	= Tree biomass per hectare in sample plot p of stratum i ; t d.m. ha ⁻¹
$B_{TREE,p,i}$	= Tree biomass in sample plot p of stratum i ; t d.m.
$A_{PLOT,i}$	= Size of sample plot in stratum i ; ha
$B_{TREE,j,p,i}$	= Biomass of trees of species j in sample plot p of stratum i ; t d.m.
$B_{TREE,l,j,p,i}$	= Biomass of tree l of species j in sample plot p of stratum i ; t d.m.
A_i	= Stratum i area; ha
$f_j(X_{1,l}, X_{2,l}, X_{3,l}, \dots)$	= Above-ground biomass of the tree returned by the allometric equation for species j relating the measurements of tree l to the above-ground biomass of the tree; t d.m.
$V_{TREE,j}(X_{1,l}, X_{2,l}, X_{3,l}, \dots)$	= 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 .
R_j	= Root-shoot ratio for tree species j ; dimensionless
D_j	= Density (over-bark) of tree species j ; dimensionless
$BEF_{2,j}$	= Biomass expansion factor for conversion of tree stem biomass to above-ground tree biomass, for tree species j ; dimensionless

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

Step 1: Selection of the allometric equation.

Specific equations were developed in the first verification event for three different groups of species: i) rubber (hu), ii) forestry plantation (for) and iii) agroforestry plantation (agf) (see table below).

Table 8. Species groups for the development of the tree allometry.

Code	Common name	Scientific name	Species group	Code group
Ca	Caoba	<i>Swietenia macrophylla</i>	forestry	for
Ce	Cedro	<i>Cedrela odorata</i>	forestry	for
Com	Cola de marrano	<i>Cojoba arborea</i>	forestry	for
Cop	Cola de pava	<i>Cupania guatemalensis</i>	forestry	for
Lab	Laurel Blanco	<i>Cordia alliodora</i>	forestry	for
Lan	Laurel Negro	<i>Cordia gerascanthus</i>	forestry	for
Mad	Madrecacao	<i>Gliricidia sepium</i>	forestry	for
Mat	Matiliguat	<i>Tabebuia rosea</i>	forestry	for
Mel	Melina	<i>Gmelina arborea</i>	forestry	for
Pab	Palo Blanco	<i>Cybastaxdonnell-smithii</i>	forestry	for
Ram	Ramon	<i>Brosimum alicastrum</i>	forestry	for
Ros	Rosul	<i>Dalbergia stevensonii</i>	forestry	for
Saj	San Juan	<i>Vochysia guatemalensis</i>	forestry	for
Sam	Santa Maria	<i>Calophyllum brasiliense</i>	forestry	for
Tec	Teca	<i>Tectona grandis</i>	forestry	for
Rat	Rambután	<i>Nephelium lappaceum</i>	agroforestry	agf
Cf	Café	<i>Coffea arabica</i>	agroforestry	agf
Cc	Cacao	<i>Theobroma cacao</i>	agroforestry	agf
Car	Cardamomo	<i>Elettaria cardamomum</i>	agroforestry	agf
Pim	Pimienta	<i>Piper nigrum</i>	agroforestry	agf
Li	Limón	<i>Citrus limon</i>	agroforestry	agf
Mna	Mandarina	<i>Citrus reticulata</i>	agroforestry	agf
Nar	Naranja	<i>Citrus sinensis</i>	agroforestry	agf
Hu	Hule	<i>Hevea brasiliense</i>	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 was 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 9. Specific allometric equations developed in the first verification event.

Equation	R ²	RMSE	Range DBH or/and H	Sample size	Code group
$V_{TREE,j}(X_{1,l},X_{2,l},X_{3,l},...) = 0.078738 * D_{30}^{1.532569} * H^{0.688972}$	0.897	0.025	$H < 1.30$ m	115	for hu
$V_{TREE,j}(X_{1,l},X_{2,l},X_{3,l},...) = 0.14378 * DBH^{1.91252} * H^{0.45610}$	0.969	0.373	$H > 1.30$ m and $DBH < 5$ cm	111	hu
$V_{TREE,j}(X_{1,l},X_{2,l},X_{3,l},...) = 0.23691 * DBH^{1.10198} * H$	0.738	0.837	$H > 1.30$ m and $DBH < 10$ cm	63	for
$V_{TREE,j}(X_{1,l},X_{2,l},X_{3,l},...) = 0.06012 * D_{30}^{1.622765} * H$	0.989	0.018	$H < 1.30$ m	31	agf
$V_{TREE,j}(X_{1,l},X_{2,l},X_{3,l},...) = 0.2741 * DBH^{1.10346} * H^{1.13244}$	0.898	0.640	$H > 1.30$ m and $DBH < 10$ cm	38	agf

H = Total height; m

DBH = Diameter at breast height; cm

D_{30} = Diameter at 30 cm; cm

$V_{TREE,j}(X_{1,l},X_{2,l},X_{3,l},...) =$ Stem volume; dm³

$RMSE$ = Root Mean Square error; dm³

Step 2: Selection of other allometric equations.

In addition, two more allometric equations were used in the project for the larger trees: i) the equation used by Arreaga (2002) in the thesis (M. Sc) “Carbon storage in forests with sustainable forest management in the Maya Biosphere Reserve, Petén, Guatemala”, was used for broadleaved species with DBH larger than 10 cm; and ii) the rubber allometric equation developed in Guatemala by Morales Ralda (2000) was used to estimate aboveground biomass of rubber trees with DBH larger than 5 cm.

Table 10. Other tree allometry used in the project.

Source	Range DBH (cm) or/and H (m)	Code group	Equation
Arreaga (2002)	$DBH > 10$ cm	for agf	$f_j(X_{1,l},X_{2,l},X_{3,l},...) = 10^{(-4,09992+(2,57782*LOG10(DBH)))}$
Morales Ralda 2000 and PICA 2010	$DBH > 5$ cm	hu	$f_j(X_{1,l},X_{2,l},X_{3,l},...) = 0.75 * DBH^2$

H = Total height; m

DBH = Diameter at breast height; cm

$f_{ij}(x_{1,i}, x_{2,i}, x_{3,i}, \dots) = \text{Aboveground biomass; Kg d.m.}$

As Arreaga (2002) equation was selected in this second verification and was not included in the PD, it was considered a Project Description Deviation.

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 aboveground biomass per tree ($f_{ij}(x_{1,i}, x_{2,i}, x_{3,i}, \dots)$) based on the tree variables measured and using the selected allometric equation or results of $V_{TREE,ij}(x_{1,i}, x_{2,i}, x_{3,i}, \dots)$, BEF_2 and D_{ij} .

See results in Excel file

“LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx”;

- Sub-step 3.2: Calculation of tree biomass ($B_{TREE,ij,D,i}$) 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: ($R_j = \exp[-1.085 + 0.9256 \cdot \ln(AGB)] / AGB$) (see results in Excel file “LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx”).
- Sub-step 3.3: Calculation of the carbon stock in tree biomass within the project boundary at t_2 ($C_{TREE_PROJ,t2}$, second monitoring ending date) and t_1 ($C_{TREE_PROJ,t1}$, second monitoring ending date). $C_{TREE_PROJ,t2}$ is calculated in the Excel file “LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx” based on equations 6 to 14 (see summary results in table below), $C_{TREE_PROJ,t1}$ results come from the previous verification report and monitoring report;
- 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 8.35 % (calculated using equations 15 of AR-TOOL14). As the uncertainty is not greater than 10%, it was not necessary to use the uncertainty discount factors provided by Table 1 in Appendix-2 of AR-TOOL14.

Table 11. Summary results of the estimation of b_{TREE} (t d.m./ha) for the stratified random sampling.

Stratum	A_i (ha)	A_{PLOT} (ha)	n_i	w_i	$b_{TREE,ij}$ (t d.m./ha)
Forestal 0-10	164.44	0.0201	15	0.10	59.32
Forestal 10-30	149.30	0.0201	14	0.09	45.88
Forestal 30-100	203.06	0.0201	10	0.13	12.32
Hule 0-10/2013-14	374.74	0.0380	50	0.23	110.80
Hule 0-10/2015-16	387.06	0.0380	52	0.24	82.09
Hule 10-30	141.64	0.0380	19	0.09	121.55
Hule 30-100	46.87	0.0380	10	0.03	62.78

Stratum	A_i (ha)	A_{PLOT} (ha)	n_i	w_i	$b_{TREE,i}$ (t d.m./ha)
SAF	80.36	0.0201	17	0.05	24.59
Huerto	68.43	0.0707	13	0.04	9.54
Total	1,615.91	-	200	1.00	Weighted mean 58.76

Table 12. Uncertainty of $C_{TREE_PROJ, t1}$.

b_{TREE} (t d.m./ha)	71.29
t_{val}	1.65
u_c (%)	8.31%
CF	0.47
B_{TREE} (t d.m.)	115,191.17
C_{TREE} (t CO ₂ -e)	198,512.78

Based on the results of above tables and the $\Delta C_{TREE_PROJ,t}$ value from first verification, a ΔC_{TREE_PROJ} value of **174,673.27 t CO₂-e** has been calculated ($\Delta C_{TREE_PROJ,t} = \Delta C_{TREE_PROJ} / T = 174.753,14 / 4.95 = 35,267.74$ t CO₂-e).

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

The change in carbon stock in dead wood was calculated using the conservative default-factor based method included in section 6.2. of AR-TOOL12. Therefore, carbon stock in dead wood in stratum i at a given point of time in year t is calculated using the following equation:

$$C_{DW,i} = C_{TREE,i} * DF_{DW} \quad (\text{Equation 16, 9 of AR-TOOL12})$$

Where:

- $C_{DW,i}$ = Carbon stock in dead wood in stratum i ; t CO₂-e;
- $C_{TREE,i}$ = Carbon stock in trees biomass in stratum i ; t CO₂-e;
- DF_{DW} = Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass; per cent.

As a conservative assumption the DF_{DW} selected from section 8.1. (Data/Parameter table 4) of AR-TOOL12 was 6 % (tropical biome; elevation < 2000 m: and annual precipitation between 1000 and 1600 mm yr⁻¹). Therefore: $\Delta C_{DW} = \Delta C_{TREE} \times DF_{DW} = 174,673.27$ t CO₂-e $\times$ 6% = **10,480.40 t CO₂-e**.

The change in carbon stock in dead wood ($\Delta C_{DW_PROJ,t}$) was calculated based on the results of the application of above equation 16 and using equations 8, 10 and 11 of AR-TOOL12.

$$C_{DW,t} = \sum_i C_{DW,i,t} \quad (\text{Equation 17, 8 of AR-TOOL12})$$

$$dC_{DW(t1,t2)} = \frac{(C_{DW,t2} - C_{DW,t1})}{T} \quad (\text{Equation 18, 10 of AR-TOOL12})$$

$$\Delta C_{DW_PROJ,t} = dC_{DW(t1,t2)} \times 1\text{year} \quad (\text{Equation 19, 11 of AR-TOOL12})$$

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;
$C_{DW,t}$	= Carbon stock in dead wood within the project boundary at a point of time in year t (e.g: t_1 and t_2); t CO ₂ -e
$dC_{DW(t1,t2)}$	= Rate of change in carbon stock in dead wood within the project boundary during the period between a point of time in year t_1 and a point of time in year t_2 ; t CO ₂ -e yr ⁻¹ .
T	= Time elapsed between two successive estimations ($T=t_2 - t_1$); yr
$\Delta C_{DW_PROJ,t}$	= Change in carbon stock in dead wood within the project boundary in year t ; t CO ₂ -e

In this second verification $\Delta C_{DW_PROJ,t} = dC_{DW(t1,t2)} \times 1 \text{ year} = (C_{DW,t2} - C_{DW,t1})/T \times 1 \text{ year} = C_{DW,t2}/T \times 1 \text{ year} = 10,480.40 / 4.95 \times 1 \text{ year} = \mathbf{2,116.06 \text{ t CO}_2\text{-e}}$.

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

Change in carbon stocks in dead wood in the project was 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:

$$C_{LI,i,t} = C_{TREE,i,t} \times DF_{LI} \quad (\text{Equation 20, 15 of AR-TOOL12})$$

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.

DF_{LI} is 1% (tropical biome, elevation < 2000 m and precipitation > 1600 mm), therefore: $C_{LI,i,t2} = C_{TREE,i,t2} \times DF_{LI} = 174.673,27 \text{ t CO}_2\text{-e} \times 1\% = \mathbf{1,746.73 \text{ t CO}_2\text{-e}}$.

In this second verification $\Delta C_{LI_PROJ,t} = dC_{LI(t1,t2)} \times 1 \text{ year} = (C_{LI,t2} - C_{LI,t1})/T \times 1 \text{ year} = C_{LI,t2}/T \times 1 \text{ year} = (1,746.73 - 238.40) / 4.95 \times 1 \text{ year} = \mathbf{352.68 \text{ t CO}_2\text{-e}}$.

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 “LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx”, and results are summarized in the following table.

Table 13. Summary results in the calculation of $C_{SHRUB,t2}$.

Stratum	$CC_{SHRUB,i}$	$b_{SHRUB,i}$	$A_{SHRUB,i}$	$b_{SHRUB,i} * A_{SHRUB,i}$		
Forestal 0-10	0.47	17.56	164.44	2,887.70		
Forestal 10-30	0.62	23.14	149.30	3,455.36		
Forestal 30-100	0.29	10.64	203.06	2,159.64		
Hule 0-10/2013-14	0.50	18.56	374.74	6,956.08		
Hule 0-10/2015-16	0.55	20.45	387.06	7,916.44		
Hule 10-30	0.62	23.07	141.64	3,268.04		
Hule 30-100	0.43	25.93	46.87	1,215.56		
SAF	0.70	16.08	80.36	1,291.90		
Huerto	0.45	25.93	68.43	1,774.71	$C_{SHRUB,t}$	$\Delta C_{SHRUB_PROJ,t}$
Total	0.516	-	1,615.91	30,925.44	74,612.77	9,529.32

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

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 in year t was calculated applying equation 8 of this methodology:

$$\Delta C_{SOC_PROJ,t} = \frac{44}{12} \times \sum_{i=1}^t A_{PLANT,t} \times dSOC_{t,i} \times 1 \text{ year} \quad (\text{Equation 21, 8 of AR-AM0016})$$

Where:

$\Delta C_{SOC_PROJ,t}$ = 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.

i = 1, 2, 3, ... strata of areas of land; dimensionless.

$$dSOC_{t,i} = \frac{SOC_{REF,i} - (SOC_{INITIAL,i} - SOC_{LOSS,i})}{20 \text{ years}} \quad \text{for } t_{PREP,i} < t \leq t_{PREP,i} + 20 \quad \text{Equation 22, 6 of AR-AM0016}$$

Where:

$SOC_{REF,i}$	= 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 .
$SOC_{LOSS,i}$	= 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 .
$t_{PREP,i}$	= The year in which first soil disturbance takes place in stratum i of the areas of land.

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.

$$SOC_{INITIAL,i} = SOC_{REF,i} \times f_{LU,i} \times f_{MG,i} \times f_{IN,i} \quad \text{Equation 23, 1 of AR-AM0016}$$

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.

SOC_{REF} and stock change factors (f_{LU} , f_{MG} and f_{IN}) were 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.

Estimations of $\Delta C_{SOC_PROJ,t}$, for the second verification of the first project activity instance are summarized in the following table and included in the Excel file “LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx”.

Table 14. Summary results of $\Delta C_{SOC_PROJ,t}$ calculations.

Project year	$\Delta C_{SOC_PROJ,t}$ Annual carbon stock change (t CO _{2-e} yr ⁻¹)	$\Delta C_{SOC_PROJ,t}$ Cumulative carbon stock change (t CO _{2-e} yr ⁻¹)
2016 ¹²	2,119.84	2,119.84
2017	4,726.84	6,846.67
2018	4,726.84	11,573.51
2019	4,726.84	16,300.35
2020	4,726.84	21,027.19
2021 ¹³	2,449.00	23,476.19
TOTAL	23,476.19	23,476.19

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”¹⁴ and considering 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. During the second verification period no forest fires have been reported, therefore GHG emissions have been considered zero.

¹² Since 20, July

¹³ Until 8, July

¹⁴ Annex 31 of the Executive Board report at its 65th meeting.

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

Actual net GHG removals by sink were calculated in an Excel file available to VVB on request ("LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.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 results of $\Delta C_{ACTUAL,t}$ are included in the following table:

Table 15. 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
2016 ¹⁵	15,772.52	4,261.72	946.35	157.73	2,119.84	23,258.15
2017	35,169.77	9,502.85	2,110.19	351.70	4,726.84	51,861.34
2018	35,169.77	9,502.85	2,110.19	351.70	4,726.84	51,861.34
2019	35,169.77	9,502.85	2,110.19	351.70	4,726.84	51,861.34
2020	35,169.77	9,502.85	2,110.19	351.70	4,726.84	51,861.34
2021 ¹⁶	18,221.67	4,923.48	1,093.30	182.22	2,449.00	26,869.67
TOTAL	174,673.27	47,196.60	10,480.40	1,746.73	23,476.19	257,573.19
Mean/Year	35,267.74	9,529.32	2,116.06	352.68	4,740.00	52,005.80

Other project emissions

In this second verification 141.68 ha were removed from the project area. In the first verification it was included the first project activity instance, being a total of 1,757.59 ha. Thus, the project area in this monitoring period corresponding to the first instance is 1,615.91 ha. The total area excluded is 8.06% regarding the area included in the first verification.

The estimated loss sums up to 3,693 t CO₂-e. It supposes a 6.74 % of the total GHG credits issued as VCUs. Loss event is defined in the VCS Program Definition as a "loss of five percent of previously verified emission reductions and removals". Thus, it can be concluded that a loss event has occurred.

5.3 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-TOOL15¹⁷.

¹⁵ Since 20, July

¹⁶ Until 8, July

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

In the project area of the first activity instance, as described in sections 1.1, 1.13 and 2.4. of the PD, there was not any agricultural activity pervious to the project activity. Therefore, there has not been displacement of agricultural activities and leakage for the first instance will be set equal to zero ($LK_t=0$).

5.4 Net GHG Emission Reductions and Removals

Net GHG removals by sink are calculated using the following equation of AR-ACM0003:

$$\Delta C_{ARR-VCS,t} = \Delta C_{ACTUAL,t} - \Delta C_{BLS,t} - LK_t \quad \text{Equation 22, 5 of AR-ACM0003}$$

Where:

- $\Delta C_{ARR-VCS,t}$ = Net anthropogenic GHG removals by sinks, in year t ; t CO₂-e
- $\Delta C_{ACTUAL,t}$ = Actual net GHG removals by sinks, in year t ; t CO₂-e
- $\Delta C_{BLS,t}$ = Baseline net GHG removals by sinks, in year t ; t CO₂-e
- LK_t = GHG emissions due to leakage, in year t ; t CO₂-e

Net GHG removals by sinks in the second monitoring period of this first project activity instance are summarized in the following table (calculations are available in the Excel file “LV_FUNDAECO_2021_2nd_verification_Field_data_GHG_estimations.xlsx”).

Table 16. Net GHG removals by sinks

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)	Buffer pool allocation	VCUs eligible for issuance
2016 ¹⁸	0	19,565.15	0	19,565.15	2,348	17,217
2017	0	51,861.34	0	51,861.34	6,223	45,638
2018	0	51,861.34	0	51,861.34	6,223	45,638
2019	0	51,861.34	0	51,861.34	6,223	45,638
2020	0	51,861.34	0	51,861.34	6,223	45,638

¹⁸ Since 20, July

2021 ¹⁹	0	26,869.67	0	26,869.67	3,224	23,646
Total	0	253,880	0	253,880	30,464	223,415

The ex-post estimation of net GHG removals by sinks in this second verification period is 253,880 t CO₂-e. As the non-permanence risk rating is 12% (as determined in the AFOLU non-permanence risk report attached as a separate document), the total number of buffer credits that need to be deposited into the AFOLU pooled buffer account is **30,464 t CO₂-e**.

The number of expected GHG credits in this second verification plus the number of credits issued in first verification event does not exceed the long-term average GHG benefit (See Appendix): VCU_s < Long term average (253,880 - 30,464 + 54,782 = 278,198 < 1,102,524). Thus, the number of GHG credits eligible to be issued as VCUs for the first project activity instance in this monitoring period is **223,415 t CO₂-e**.

¹⁹ Until 8, July

APPENDIX 1: LONG-TERM AVERAGE GHG BENEFIT CALCULATION

Section 3.2.21 of the VCS Standard v4.1 states “The long-term average GHG benefit shall be calculated at each verification event”. Thus, in this second verification event, the long-term average GHG benefit was recalculated based on the forest management plan agreed between FUNDAECO and LIVELIHOODS, the results of the monitoring and the updated project area considering the 57 properties have been removed from the original project area.

Baseline emissions:

As per PD, baseline emissions are accounted as zero.

Project emissions:

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

Following the established forest management plan, all plantation systems are under conservation easements with no intention to harvest after the project crediting period. However, forest plantations system includes intermediate thinning every 6 years since year 9 until reaching a planting density of 200-250 trees per hectare. The stand volume removals in each thinning will be 30% of the total.

For this second verification event, each plantation system (i.e., rubber, AFS, forest plantation and orchards) growth models were updated considering results of the monitoring and more realistic and conservative growth rates based on the planted species and local data.

Although mean annual increment (MAI) was considered in the PD when estimating the tree growth, the current annual increment (CAI) was considered to calculate the long-term average in the second verification event. Although this approach is more conservative for the first years of the project where the biomass growth is slower, in the long term, both alternatives achieve the same amount of GHG removal. However, CAI was considered because the results are more consistent with those obtained in this verification.

AGB growth models were created based on AGB data at different ages (including results of field monitoring from this verification event) and the Chapman-Richards function (Richards, 1959²⁰; Pienaar and Turnbull, 1973²¹). The Chapman-Richards function depends on three parameters: growth speed, curve shape and AGB maximum value. For the case of AFS, an AGB value of 72.2 t d.m./ha²². Where mean AGB values were found in bibliography, these values were used as reference. In other cases, the Chapman-Richard function was fitted to achieve the 30-year MAI reported in bibliography for each plantation system.

Forest plantation growth models were fitted for the main species found in this verification event, taking in account the number of trees of each species and the basal area. In addition, the thinning plan was

²⁰ Richards, F.J. 1959. A flexible growth function for empirical use. Journal of Experimental Botany. 10: 290-300.

²¹ Pienaar, L.V.; Turnbull, K.J. 1973. The Chapman-Richards generalization of Von Bertalanffy's growth model for basal area growth and yield in even-aged stands. Forest Science. 19(1): 2-22.

²² Dávila Romero, H. A. (2014). Estimación de la cantidad de carbono almacenado en los sistemas agroforestales de cacao (*Theobroma cacao* L.), en los Departamentos de Suchitepéquez y Retalhuleu del Sur-Occidente de Guatemala, CA (Doctoral dissertation, Universidad de San Carlos de Guatemala).

considered in their fitting. Where INSTITUTO NACIONAL DE BOSQUES, 2014 data were used, only values reported for El Estor and Livingston departments in Izabal were considered. The following table summarizes AGB mean annual increment values used to fit each growth model.

Table 17. AGB mean annual increment.

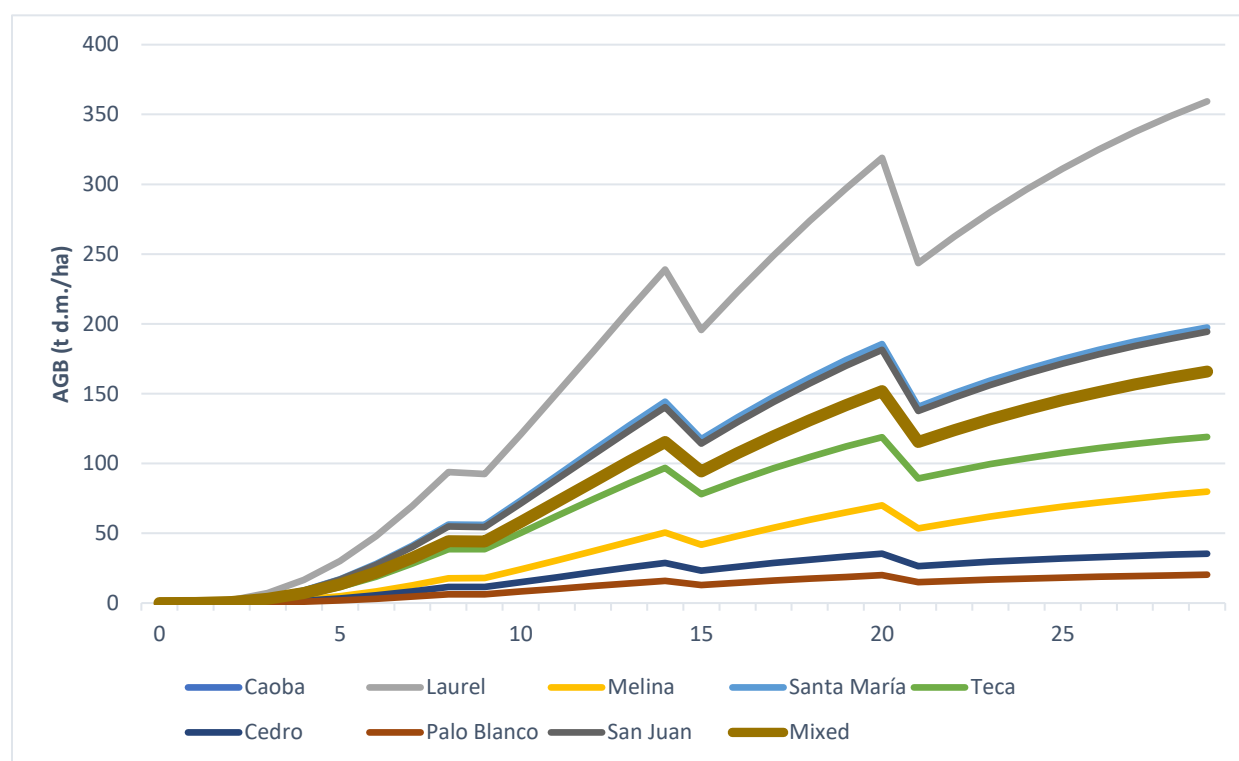
Species/Planting system	MAI (t d.m./ha/year)	Source
Rubber	14.15	PICA 2013 Monitoring Report ²³
Orchards	1.23	Based on mixed forest plantations ²⁴
Caoba	15.58	INSTITUTO NACIONAL DE BOSQUES, 2014
Laurel	12.5	INAB, FAO/FFF, 2016
San Juan	9.41	INSTITUTO NACIONAL DE BOSQUES, 2014
Melina	3.86	INSTITUTO NACIONAL DE BOSQUES, 2014
Santa Maria	9.54	INSTITUTO NACIONAL DE BOSQUES, 2014
Palo Blanco	0.98	INSTITUTO NACIONAL DE BOSQUES, 2014
Cedro	1.70	Instituto Nacional de Bosques. 2019
Teca	5.74	INSTITUTO NACIONAL DE BOSQUES, 2014
Mixed forest plantations	7.39	Mean of above forest plantation species MAI

The following figure illustrates the growth models developed for the forest plantation species. The mixed forest plantation MAI value was considered to be the mean of all forestry species as a conservative and simplified approach.

²³ 2013 Monitoring Report of the VCS ARR Project: Promoting sustainable development through natural Rubber tree plantation in Guatemala.

²⁴ This value was derived considering the AGB MAI in orchards is a 18% of Forest plantations, based on the relation between the planting densities of both systems (17*204/1111).

Figure 2. Growth models for forest plantation system species.



Ex-ante estimations of change in carbon stock in trees for long-term average GHG benefit calculation (ΔC_{TREE}) follow the steps described in PD. However, planting plan was modified to consider the properties that were removed from the original project area (Table 2).

Table 18. Updated planting plan.

Project year	$C_{TREE,t}$				
	Forest	Orchards	Rubber	AFS	Total
2013	61.86	1.52	38.90	20.48	122.77
2014	148.56	2.86	418.95	35.01	605.38
2015	255.64	59.60	434.67	24.00	773.91
2016	50.75	4.45	57.79	0.86	113.86
Total	516.81	68.43	950.31	80.36	1,615.91

Table 19. Change in carbon stock in tree biomass in project.

Project year	$C_{TREE,t}$					$\Delta C_{TREE_PROJ,t}$
	Rubber	Forest	AFS	Orchards	Total	Total
2013	92.84	12.75	44.39	0.00	149.98	149.98
2014	1,516.38	162.23	224.10	0.11	1,902.83	1,752.84
2015	7,927.04	848.22	593.90	1.14	9,370.30	7,467.47
2016	22,689.89	2,844.89	1,119.38	8.95	26,663.11	17,292.81
2017	46,329.12	6,967.53	1,739.04	46.65	55,082.34	28,419.23
2018	77,706.97	13,726.47	2,410.03	150.88	93,994.34	38,912.00
2019	115,101.20	23,260.79	3,102.20	349.86	141,814.06	47,819.72
2020	156,691.44	35,411.08	3,792.07	649.00	196,543.58	54,729.52
2021	200,683.81	47,760.22	4,467.55	1,031.98	253,943.55	57,399.97
2022	245,994.06	59,028.10	5,120.60	1,470.15	311,612.91	57,669.36
2023	291,491.37	68,051.90	5,743.17	1,932.39	367,218.83	55,605.92
2024	335,958.13	84,760.72	6,327.55	2,391.58	429,437.98	62,219.15
2025	378,855.60	103,558.33	6,873.96	2,827.55	492,115.44	62,677.45
2026	419,744.84	122,376.44	7,381.81	3,227.38	552,730.47	60,615.03
2027	458,319.78	135,544.06	7,851.42	3,584.38	605,299.65	52,569.18
2028	494,401.98	140,672.86	8,283.85	3,896.55	647,255.25	41,955.60
2029	527,912.54	135,822.55	8,680.63	4,165.08	676,580.79	29,325.54
2030	558,848.14	147,935.07	9,043.59	4,393.09	720,219.89	43,639.10
2031	587,261.31	163,523.86	9,374.75	4,584.73	764,744.65	44,524.75
2032	613,244.31	178,130.64	9,676.24	4,744.47	805,795.66	41,051.01
2033	636,916.36	184,667.12	9,950.18	4,876.78	836,410.44	30,614.78
2034	658,413.70	180,303.95	10,198.68	4,985.78	853,902.12	17,491.67
2035	677,881.84	162,740.75	10,423.78	5,075.22	856,121.58	2,219.47
2036	695,469.77	167,672.90	10,627.41	5,148.35	878,918.44	22,796.85
2037	711,325.74	177,507.57	10,811.43	5,207.99	904,852.72	25,934.29
2038	725,594.11	186,488.93	10,977.55	5,256.53	928,317.11	23,464.39
2039	738,413.29	194,670.39	11,127.39	5,295.96	949,507.03	21,189.91
2040	749,914.33	202,106.74	11,262.45	5,327.94	968,611.46	19,104.43
2041	760,220.07	208,852.73	11,384.09	5,353.86	985,810.76	17,199.30
2042	769,444.78	214,962.03	11,493.59	5,374.84	1,001,275.25	15,464.49

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

Changes in carbon stock in shrub biomass were conservative accounted considering only to-date monitored data in first and second verification events between 2013-2021.

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

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:

$$C_{LI,i,t} = C_{TREE,i,t} \times DF_{LI} \quad (\text{Equation 20, 15 of AR-TOOL12})$$

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.

DF_{LI} is 1% (tropical biome, elevation < 2000 m and precipitation > 1600 mm).

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

The change in carbon stock in dead wood was calculated using the conservative default-factor based method included in section 6.2. of AR-TOOL12. Therefore, carbon stock in dead wood in stratum i at a given point of time in year t is calculated using the following equation:

$$C_{DW,i} = C_{TREE,i} * DF_{DW} \quad (\text{Equation 16, 9 of AR-TOOL12})$$

Where:

$C_{DW,i}$	= Carbon stock in dead wood in stratum i ; t CO ₂ -e;
$C_{TREE,i}$	= Carbon stock in trees biomass in stratum i ; 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.

As a conservative assumption the DF_{DW} selected from section 8.1. (Data/Parameter table 4) of AR-TOOL12 was 6 % (tropical biome; elevation < 2000 m: and annual precipitation between 1000 and 1600 mm yr⁻¹).

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

Changes in carbon stocks in the SOC pool were calculated as per PD. However, estimations were updated using the project area from second verification (i.e., without the properties that were removed from the original project area)

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

As per PD and considering that no forest fires have occurred within the project area, for ex ante estimations emission of non-CO₂ GHG resulting from fires was considered zero.

Leakage emissions:

As per PD, leakage emissions are accounted as zero.

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, based on equation 2 of the methodology ($\Delta C_{ACTUAL,t} = \Delta C_{P,t} - GHG_{E,t}$), 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 20. Change in carbon stock in tree biomass in project for all plantation systems except forest plantation.

Project year	$\Delta C_{TREE,t}$	$\Delta C_{SHRUB,t}$	$\Delta C_{DW,t}$	$\Delta C_{LI,t}$	$\Delta C_{SOC,t}$	$\Delta C_{PROJ,t}$
	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e
2013	137.23	2,250.60	8.23	1.37	178.66	2,576.10
2014	1,603.36	6,430.28	96.20	16.03	1,518.67	9,664.55
2015	6,781.48	6,430.28	406.89	67.81	3,038.93	16,725.40
2016	15,296.15	6,435.38	917.77	152.96	3,224.04	26,026.29
2017	24,296.59	6,463.61	1,457.80	242.97	3,224.04	35,684.99
2018	32,153.07	6,463.61	1,929.18	321.53	3,224.04	44,091.42
2019	38,285.40	6,463.61	2,297.12	382.85	3,224.04	50,653.02
2020	42,579.24	0.00	2,554.75	425.79	3,224.04	48,783.82
2021	45,050.83	0.00	2,703.05	450.51	3,224.04	51,428.42
2022	46,401.48	0.00	2,784.09	464.01	3,224.04	52,873.62
2023	46,582.11	0.00	2,794.93	465.82	3,224.04	53,066.90
2024	45,510.33	0.00	2,730.62	455.10	3,224.04	51,920.09
2025	43,879.84	0.00	2,632.79	438.80	3,224.04	50,175.47
2026	41,796.92	0.00	2,507.82	417.97	3,224.04	47,946.75
2027	39,401.56	0.00	2,364.09	394.02	3,224.04	45,383.70
2028	36,826.80	0.00	2,209.61	368.27	3,224.04	42,628.71
2029	34,175.85	0.00	2,050.55	341.76	3,224.04	39,792.20
2030	31,526.58	0.00	1,891.59	315.27	3,224.04	36,957.47
2031	28,935.97	0.00	1,736.16	289.36	3,224.04	34,185.52

2032	26,444.23	0.00	1,586.65	264.44	3,224.04	31,519.36
2033	24,078.31	0.00	1,444.70	240.78	3,045.38	28,809.16
2034	21,854.85	0.00	1,311.29	218.55	1,705.36	25,090.05
2035	19,782.66	0.00	1,186.96	197.83	185.10	21,352.55
2036	17,864.70	0.00	1,071.88	178.65	0.00	19,115.23
2037	16,099.62	0.00	965.98	161.00	0.00	17,226.59
2038	14,483.03	0.00	868.98	144.83	0.00	15,496.84
2039	13,008.45	0.00	780.51	130.08	0.00	13,919.05
2040	11,668.08	0.00	700.08	116.68	0.00	12,484.84
2041	10,453.31	0.00	627.20	104.53	0.00	11,185.04
2042	9,355.19	0.00	561.31	93.55	0.00	10,010.05

Table 21. Change in carbon stock in tree biomass in project for forest plantation system.

Project year	$\Delta C_{TREE,t}$	$\Delta C_{SHRUB,t}$	$\Delta C_{DW,t}$	$\Delta C_{LI,t}$	$\Delta C_{SOC,t}$	$\Delta C_{PROJ,t}$
	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e
2013	12.75	1,058.25	0.77	0.13	181.45	1,253.34
2014	149.48	3,023.57	8.97	1.49	617.22	3,800.74
2015	685.99	3,023.57	41.16	6.86	1,367.09	5,124.67
2016	1,996.66	3,025.97	119.80	19.97	1,515.97	6,678.36
2017	4,122.65	3,039.24	247.36	41.23	1,515.97	8,966.44
2018	6,758.93	3,039.24	405.54	67.59	1,515.97	11,787.27
2019	9,534.32	3,039.24	572.06	95.34	1,515.97	14,756.94
2020	12,150.29	0.00	729.02	121.50	1,515.97	14,516.77
2021	12,349.14	0.00	740.95	123.49	1,515.97	14,729.55
2022	11,267.88	0.00	676.07	112.68	1,515.97	13,572.60
2023	9,023.81	0.00	541.43	90.24	1,515.97	11,171.44
2024	16,708.82	0.00	1,002.53	167.09	1,515.97	19,394.40
2025	18,797.61	0.00	1,127.86	187.98	1,515.97	21,629.41
2026	18,818.11	0.00	1,129.09	188.18	1,515.97	21,651.35
2027	13,167.62	0.00	790.06	131.68	1,515.97	15,605.32
2028	5,128.80	0.00	307.73	51.29	1,515.97	7,003.79
2029	-4,850.32	0.00	-291.02	-48.50	1,515.97	-3,673.87
2030	12,112.53	0.00	726.75	121.13	1,515.97	14,476.37
2031	15,588.79	0.00	935.33	155.89	1,515.97	18,195.97
2032	14,606.78	0.00	876.41	146.07	1,515.97	17,145.22
2033	6,536.48	0.00	392.19	65.36	1,334.52	8,328.55
2034	-4,363.17	0.00	-261.79	-43.63	898.75	-3,769.85
2035	-17,563.20	0.00	-1,053.79	-175.63	148.88	-18,643.74
2036	4,932.15	0.00	295.93	49.32	0.00	5,277.40
2037	9,834.67	0.00	590.08	98.35	0.00	10,523.09
2038	8,981.36	0.00	538.88	89.81	0.00	9,610.06

2039	8,181.46	0.00	490.89	81.81	0.00	8,754.16
2040	7,436.35	0.00	446.18	74.36	0.00	7,956.90
2041	6,746.00	0.00	404.76	67.46	0.00	7,218.22
2042	6,109.30	0.00	366.56	61.09	0.00	6,536.95

Long-term average GHG Benefit

Calculations of the long-term average GHG benefit were done only for forest plantation system following Section 3.2.21 of the VCS Standard v4.1 and The VCS Program guidance document AFOLU Guidance: Example for Calculating the Long-Term Average Carbon Stock for ARR Projects with Harvesting, available on the Verra website.

Table 22. Long-term average GHG Benefit summary for all plantation systems except forest plantation.

	Baseline scenario: to-date GHG emission reductions and removals at year t	Project scenario: to- date GHG emission reductions and removals at year t	Expected total GHG benefit to-date	Annual change in GHG benefit
Project year t	t CO ₂ -e BE	t CO ₂ -e PE	t CO ₂ -e PE _t – BE _t	t CO ₂ -e PE _t – PE _{t-1}
2013	0.00	2,576.10	2,576.10	2,576.10
2014	0.00	12,240.65	12,240.65	9,664.55
2015	0.00	28,966.05	28,966.05	16,725.40
2016	0.00	54,992.34	54,992.34	26,026.29
2017	0.00	90,677.34	90,677.34	35,684.99
2018	0.00	134,768.76	134,768.76	44,091.42
2019	0.00	185,421.78	185,421.78	50,653.02
2020	0.00	234,205.60	234,205.60	48,783.82
2021	0.00	285,634.03	285,634.03	51,428.42
2022	0.00	338,507.64	338,507.64	52,873.62
2023	0.00	391,574.54	391,574.54	53,066.90
2024	0.00	443,494.64	443,494.64	51,920.09
2025	0.00	493,670.11	493,670.11	50,175.47
2026	0.00	541,616.85	541,616.85	47,946.75
2027	0.00	587,000.56	587,000.56	45,383.70
2028	0.00	629,629.27	629,629.27	42,628.71
2029	0.00	669,421.47	669,421.47	39,792.20
2030	0.00	706,378.95	706,378.95	36,957.47
2031	0.00	740,564.47	740,564.47	34,185.52
2032	0.00	772,083.83	772,083.83	31,519.36

2033	0.00	800,893.00	800,893.00	28,809.16
2034	0.00	825,983.05	825,983.05	25,090.05
2035	0.00	847,335.60	847,335.60	21,352.55
2036	0.00	866,450.83	866,450.83	19,115.23
2037	0.00	883,677.42	883,677.42	17,226.59
2038	0.00	899,174.26	899,174.26	15,496.84
2039	0.00	913,093.31	913,093.31	13,919.05
2040	0.00	925,578.15	925,578.15	12,484.84
2041	0.00	936,763.19	936,763.19	11,185.04
2042	0.00	946,773.25	946,773.25	10,010.05
Sum			16,189,147.05	
LA			695,389.46	

Table 23. Long-term average GHG Benefit summary for forest plantation system.

	Baseline scenario: to-date GHG emission reductions and removals at year t	Project scenario: to- date GHG emission reductions and removals at year t	Expected total GHG benefit to-date	Annual change in GHG benefit
Project year	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e	t CO ₂ -e
t	BE	PE	PE _t – BE _t	PE _t – PE _{t-1}
2013	0.00	1,253.34	1,253.34	1,253.34
2014	0.00	5,054.08	5,054.08	3,800.74
2015	0.00	10,178.75	10,178.75	5,124.67
2016	0.00	16,857.11	16,857.11	6,678.36
2017	0.00	25,823.55	25,823.55	8,966.44
2018	0.00	37,610.82	37,610.82	11,787.27
2019	0.00	52,367.75	52,367.75	14,756.94
2020	0.00	66,884.53	66,884.53	14,516.77
2021	0.00	81,614.07	81,614.07	14,729.55
2022	0.00	95,186.67	95,186.67	13,572.60
2023	0.00	106,358.11	106,358.11	11,171.44
2024	0.00	125,752.52	125,752.52	19,394.40
2025	0.00	147,381.92	147,381.92	21,629.41
2026	0.00	169,033.27	169,033.27	21,651.35
2027	0.00	184,638.59	184,638.59	15,605.32
2028	0.00	191,642.38	191,642.38	7,003.79
2029	0.00	187,968.51	187,968.51	-3,673.87
2030	0.00	202,444.88	202,444.88	14,476.37

2031	0.00	220,640.85	220,640.85	18,195.97
2032	0.00	237,786.07	237,786.07	17,145.22
2033	0.00	246,114.62	246,114.62	8,328.55
2034	0.00	242,344.77	242,344.77	-3,769.85
2035	0.00	223,701.03	223,701.03	-18,643.74
2036	0.00	228,978.43	228,978.43	5,277.40
2037	0.00	239,501.53	239,501.53	10,523.09
2038	0.00	249,111.58	249,111.58	9,610.06
2039	0.00	257,865.74	257,865.74	8,754.16
2040	0.00	265,822.64	265,822.64	7,956.90
2041	0.00	273,040.85	273,040.85	7,218.22
2042	0.00	279,577.80	279,577.80	6,536.95
Sum		4,672,536.77		
LA		155,751.23		

Table 24. Long-term average GHG Benefit summary for the project area.

Project year <i>t</i>	Baseline scenario: to-date GHG emission reductions and removals at year <i>t</i>
	<i>t</i> CO ₂ -e <i>BE</i>
2013	3,829.44
2014	13,465.29
2015	21,850.07
2016	32,704.65
2017	44,651.43
2018	55,878.69
2019	65,409.95
2020	63,300.59
2021	66,157.97
2022	66,446.22
2023	64,238.34
2024	71,314.50
2025	71,804.88
2026	69,598.09
2027	60,989.02
2028	49,632.50
2029	36,118.33
2030	51,433.85
2031	52,381.49
2032	48,664.59

2033	37,137.71
2034	21,320.20
2035	2,708.81
2036	24,392.63
2037	7,095.21
2038	0.00
2039	0.00
2040	0.00
2041	0.00
2042	0.00
Sum	1,102,524.47
LA	1,102,524.47