Forest Carbon Partnership Facility (FCPF)
Carbon Fund

ER Monitoring Report (ER-MR)

ER Program Name and Country:	Guatemala
Reporting Period covered in this report:	01-01-2020 to 12-31-2020
Number of FCPF ERs:	6,259,134
Quantity of ERs allocated to the Uncertainty Buffer:	1,108,465
Quantity of ERs to allocated to the Reversal Buffer:	1,463,174
Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:	406,437
Date of Submission:	30-06-2022
Version	30-06-2023

General guidelines on completing the ER-MR. Guidance text within the ER Monitoring template shall be considered as requirements and shall be met by the ER Program.

ER Programs shall comply with the requirements of the FCPF Methodological Framework's version available at the time of ERPA signature and the latest version of other FCPF requirements such as the Buffer Guidelines, Process Guidelines, Validation and Verification Guidelines, and the Guidelines on the application of the Methodological Framework. These versions may be found in here: https://www.forestcarbonpartnership.org/requirements-and-templates

Purpose of the ER-MR

ER Programs that have been included in the portfolio of the FCPF Carbon Fund shall implement the ER Program and report on performance, in particular ERs generated. By completing and submitting the ER Monitoring Report, a REDD Country Participant or its authorized entity officially reports on its performance to the Carbon Fund.

The FCPF Glossary of Terms provides definitions of specific terms used in the Methodological Framework, Buffer Guidelines and other requirements. Unless otherwise defined in this ER-MR template, any capitalized term used in this ER-MR template shall have the same meaning ascribed to such term in the FCPF Glossary of Terms.

Guidance on completing the ER-MR

All sections of the ER-MR shall be completed. If sections of the ER-MR are not applicable, explicitly state that the section is "Intentionally left blank" and provide an explanation why this section is not applicable. All instructions, including this section, should be deleted when submitting the ER-MR to the Facility Management Team of the FCPF.

Font of the body text shall be Calibri 10 black font.

Provide definitions of key terms that are used and use these key terms, as well as variables etc, consistently using the same abbreviations, formats, subscripts, etc. If the ER –MR contains equations, please number all equations and define all variables used in these equations, with units indicated.

The presentation of values in the ER-MR, including those used for the calculation of emission reductions, should be in international standard format e.g 1,000 representing one thousand and 1.0 representing one. Please use International System Units (SI units – refer to http://www.bipm.fr/enus/3_SI/si.html) unless the MF or the IPCC Guidelines indicate otherwise (e.g. tonnes vs Mg).

REDD Country Participants should note that if the Reporting Period does not coincide with the beginning and end of a natural year it shall apply the Guidelines on the application of the MF Number 3 on reporting periods. In this case, net ERs shall be estimated for the Monitoring Period and they shall be allocated to the Reporting Period pro-rata on the number of months. In the template Monitoring Report refers to the period used for monitoring ERs, while Reporting period refers to the period defined in the ERPA and for which ERs are paid for.

REDD Country Participants should also note that if Technical Corrections to the Reference Level have been applied in accordance with the Guidelines on the application of the methodological framework number 2 on technical corrections, then the technically corrected RL shall be reported in Annex 4 and will be subject to Validation by the Validation and Verification Body.

Acronyms

AAI	average annual increments
AFSs	Agroforestry systems
ANACAFE	National Coffee Association (Spanish acronym)
BDP	Benefit Distribution Plan
CEMEC	Center for Evaluation and Monitoring (CEMEC, for its acronym in Spanish)
CEP	Collect Earth Project
CNCC	National Climate Change Council (Spanish acronym)
CONAP	National Council for Protected Areas (CONAP, for its acronym in Spanish)
ENREDD+	National REDD+ Strategy
ER	Emissions Reduction
ERPD	Emissions Reduction Document (ERPD)
ERP	Emission Reduction Program
ERPA	Emissions Reduction Payment Agreement
EF	Emission factors
FA	Absorption factors
FAO	Food and Agriculture Organization of the United Nations
FCF	Forest Fire Commission
FCPF	Forest Carbon Partnership Facility (FCPF)
FIP	Forest Investment Program (FIP)
FREL	Forest Reference Emission Levels
FUNDAECO	Foundation for Ecodevelopment and Conservation, for its acronym in English
GCI	Interinstitutional Coordination Group
GCF	Green Climate Fund (GCF)
GIMBUT	Inter-institutional Group for Forestry and Land Use Monitoring for its acronym in Spanish
GHG	Greenhouse Gases
GoG	Government of Guatemala (GoG)
GSCCC	Guatemalan Climate Change Science System of Climate Change
IBRD	International Bank for Reconstruction and Development (IBRD).
INAB	National Forest Institute (INAB, for its acronym in Spanish)
IPCC	Intergovernmental Panel on Climate Change
LULUC	Land Use, Land-Use Change and Forestry
MARN	Ministry of Environment and Natural Resources for its acronym in Spanish),
MAGA	Ministry of Agriculture, Livestock and Food for its acronym in Spanish)
MCSEAB	Mechanisms of Compensation for Environmental and Ecosystem Services for its acronym in Spanish
MINFIN	Ministry of Public Finance for its acronym in Spanish)
MRV	Monitoring, Reporting and Verification
NDC	Nationally Determined Contributions
NFI	National Forest Inventory
PINPEP	Forestry incentive program for holders of small tracts of land with forestry or agroforestry vocation.
PINFOR	Forestry incentive program
PROBOSQUE	Incentive Program for the establishment, recovery, management, production and protection of forests in Guatemala.
PPM	Parcel system permanent sampling
Plant	Forest plantations
REDD+	Reducing emissions from deforestation and forest degradation.
REDDES	Local Networks for Development for its acronym in Spanish
SIGAP	Guatemalan System of Protected Areas (SIGAP, for its acronym in Spanish)
SIREDD+,	National Information System for GHG Emissions, Multiple Benefits, Other Impacts, Management and REDD+ Safeguards for its acronym in Spanish)
SNIGT	National GHG Inventory System for its acronym in Spanish

UNFCCC	United Nations Framework Convention on Climate Change
UVG	Universidad del Valle de Guatemala
VCS	Voluntary Carbon Standards (VCS)
WCS	Wildlife Conservation Society

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1 IMPLEMENTATION AND OPERATION OF THE ER PROGRAM DURING THE REPORTING PERIOD

1.1 Implementation status of the ER Program and changes compared to the ER-PD

Implementation status of the ER Program and changes compared to the Emission Reduction Program Document (ERPD).

In this first Emissions Reduction (ER) Monitoring Report of Guatemala, the progress that the country has made to address the main causes of deforestation and forest degradation is reported, compared to what is established in the Emissions Reduction Document (ERPD). The most relevant milestones are provided below.

- **Establishment of the Executing Unit:** Article 5 of Decree 20-2020, issued by the Congress of the Republic on April 15, 2020, established the Executing Unit of the ER Program to be developed through the National Forest Institute (*INAB, for its acronym in Spanish*), who will coordinate actions with the Ministry of Environment and Natural Resources (*MARN, for its acronym in Spanish*), the Ministry of Agriculture, Livestock and Food (*MAGA*, for its acronym in Spanish) and the National Council for Protected Areas (*CONAP, for its acronym in Spanish*).1

- **Signing of the ERPA:** On September 13, 2021, Guatemala formalized the historic signing of the Emissions Reduction Payment Agreement (ERPA) with the Forest Carbon Partnership Facility (FCPF), through the Program Entity, which corresponds to the Ministry of Public Finance (*MINFIN, for its acronym in Spanish*) and the International Bank for Reconstruction and Development (IBRD).

- **Launch of the National Strategy to Reduce Deforestation and Forest Degradation under the REDD+ mechanism:** On September 13, 2021, the Ministry of Environment and Natural Resources officially delivered to the President of the Republic of Guatemala the finalized document of the REDD+ National Strategy (2020-2050), being a relevant milestone in the country, to ratify its commitment to advance in the actions of the Emission Reduction Program (ERP).2

- **Approval of the INAB and CONAP institutional modalities to implement actions within the ERP:** The ERPD established that INAB and CONAP would design institutional mechanisms framed in the Emission Reduction Program. In this sense, in 2021 INAB approved, through the Board of Directors of the institution as the collegiate body, a manual on the Mechanisms of Compensation for Environmental and Ecosystem Services (*MCSEAB, for its acronym in Spanish*)3 and that same year CONAP, for its part, through the Honorable Council for Protected Areas, approved the Regulations to control and promote REDD+ actions in the Guatemalan System of Protected Areas (*SIGAP, for its acronym in Spanish*) through management models for the conservation and sustainable use of forests.

- **Registry of Projects for the Removal or Reduction of Greenhouse Gas (GHG) Emissions:** Compared to the ERPD, the Ministry of Environment and Natural Resources has achieved a historic milestone, through the establishment of the Registry of Projects for the Removal or Reduction of Greenhouse Gas (GHG) Emissions, which will allow, among its many functions, to avoid the double accounting of REDD+ initiatives subject to payment based on results. The Registry was created and published in the Central American Official Newspaper in August 2020, through Ministerial Agreement 284-2020. Said Registry establishes the creation of operating and procedure manuals, which were prepared in 2021 and are in the process of being approved, with an 80% progress rate.4

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1 https://www.congreso.gob.gt/detalle_pdf/decretos/13525#gsc.tab=0

2 https://twitter.com/marngt/status/1448303019649556485

3
https://www.inab.gob.gt/images/informacionpublica/manuales/6.52%20Manual%20de%20Normas,%20Procesos%20y%20Procedimientos%20del%20Departamento%20de%20Conservacion%20de%20Ecosistemas%20Forestales.pdf

4 http://www.snicc.marn.gob.gt/Content/PDF/Reglamento_Registro_de_Proyectos.pdf

- **ERP Benefit Distribution Plan (BDP):** Compared to the ERPD, Guatemala has developed the technical, administrative and legal procedures to ensure the distribution of the benefits derived from the ER Program. The BDP includes the feedback of the entities participating in the Program and the consultations carried out with project beneficiaries in order to obtain approval. The BDP also has a Nesting Protocol that describes the methodological integration of existing REDD+ initiatives within the ER Program, in order to avoid double carbon accounting.

- Progress in actions and interventions under the ER Program: The Government of Guatemala has defined a total of 19 REDD+ actions for the ERP, which have been grouped into 5 major strategic options, under a programmatic-based approach, which are closely related to the national efforts that are currently being developed in the country to address deforestation and forest degradation. Emission reduction activities within the framework of the ERP may be implemented through any of the following three modalities: 1. REDD+ Project Initiative; 2. Initiative for compensation mechanisms for ecosystem and environmental services associated with forests; and, 3. Management Models Initiative for the conservation and sustainable use of forests in the SIGAP.

  For the 2020 period, only the REDD+ Project Initiative implemented activities. These projects are: a) GUATECARBON REDD+ Project; b) Lacandón - Forests for Life REDD+ Project; c) (Early) Local Networks for Development (*REDDES, for its acronym in Spanish*) REDD+ Project. Projects a and b are certified by the Voluntary Carbon Standards (VCS), and project c is in the process of being certified by the Verra Verified Carbon Standard (VCS). This represents a relevant milestone for Guatemala, since they are the first initiatives that, within the framework of the ERP, have carried out Emission Reduction activities.

- Progress in Emission Reduction activities despite COVID-19: On March 6, 2020, through Government Decree 5-2020, a state of calamity was declared in the country as a result of the official pronouncement of the World Health Organization, which identified the virus called COVID-19 as an international public health emergency. In this sense, the right of free locomotion and conglomerations of people at the national level were limited. Therefore, the REDD+ activities planned by the Guatemalan Government and the REDD+ projects were limited due to the restrictions established by the Guatemalan Ministry of Health. However, despite the aforementioned, in 2020 institutional actions were continued in conjunction with stakeholders from the forestry, environmental and justice sectors through compliance with the current national regulatory framework, such as the Law of Protected Areas and its Regulations, Decree No. 4-89, the Master Plan for the Mayan Biosphere Reserve, the model of community forestry concessions, the PINPEP and PROBOSQUE Laws, among others of a similar nature.

Update on the strategy to mitigate and/or minimize potential displacement:

The risk due to displacement during the year 2020 in the area of intervention of the Program continued to be moderate, since no risks of high impact on the environment and society were identified that have led to displacement activities towards the accounting area, since Guatemala has considered as a priority to increase the strengthening of forest governance, promoting the coordination and effective participation of local actors, as part of the National Plan for the Economic Recovery of Guatemala derived from COVID-19, following the health and safety, innovation and sustainability cross-cutting principles:

The risk of displacement of emissions during the year 2020 outside the accounting area, such as the Laguna del Tigre National Park (area excluded from the ERP), has been managed mainly by reinforcing institutional presence through the Forest Fire Commission (FFC) of Petén, in areas of high incidence that affect the program area. INAB reported that in the 2020 period it estimated 63% fewer forest fires in the department of Petén, compared to 2019. In addition, it should be noted that CONAP has been conducting permanent monitoring in the Maya Biosphere Reserve for more than 20 years (through the Center for Evaluation and Monitoring (*CEMEC, for its acronym in Spanish*) together with the WCS (Wildlife Conservation Society), with daily data updates and public access. This has been a key mechanism for its detection and early preventive actions.

Likewise, the risk of displacement to the Sarstún-Motagua region, the second territory outside the accounting area of the ERP, is low given that the territory has been co-administered by CONAP and FUNDAECO for more than 25 years, with no expiration date, because it is established in the Law of Protected Areas and other laws declaring protected areas specific to Izabal. Additionally, remnants of forest outside the project area are highly fragmented and minimal.

Finally, Guatemala has an action plan for the National REDD+ Strategy, where it is expected that the first five years of implementation are carried out with the country's own resources and the support of climate funds, such as the Green Climate Fund (GCF) and the Nama Facility, as well as a small portion of payments based on results through the regulated or voluntary market, among others of a similar nature. This will make it possible to continue with the strategic approach to priority actions and, thus, mitigate displacement due to emissions with the support of civil society, the private sector, local communities and indigenous peoples.

Effectiveness of the organizational agreements and involvement of partner agencies:

The institutional governance framework of the ERP Program is formed by the Ministry of Public Finance (MINFIN), as the Program Entity; the National Forest Institute (INAB), as the Program's Executing Entity; and, the Ministry of Environment and Natural Resources (MARN), the National Council for Protected Areas (CONAP), and the Ministry of Agriculture, Livestock and Food (MAGA), as strategic institutional partners. In addition, various NGOs play a role as implementing partners.

Decree 20-2020 of the Congress of the Republic of Guatemala establishes that the National Forest Institute (INAB) is the Executing Unit of the Emission Reduction Program. It will also be responsible of coordinating actions with the National Council for Protected Areas (CONAP), the Ministry of Environment and Natural Resources (MARN), and the Ministry of Agriculture, Livestock and Food (MAGA).

In this sense, the Coordination Office of the Emission Reduction Program of the National Forest Institute (ERP Executing Unit) has led the preparation of the First Emissions Reduction Monitoring Report for the period from January 1 to December 31, 2020, through the creation of the Monitoring Group for the first emissions reduction monitoring report, which is made up of staff specialized in geographic information systems and climate change from MARN, MAGA, CONAP, as well as representatives of the ERP REDD+ Projects. In addition, it has received specialized support in carbon monitoring and accounting, complemented by academia (*Universidad del Valle de Guatemala*).

This type of coordination and inter-institutional arrangements has become an example at the national level since it is the first time that so many state organizations, REDD+ projects and strategic partners have come together to make a national effort to reduce deforestation and degradation of forests. These synergies will be strengthened by the second and third monitoring reports.

Updates on the assumptions in the financial plan and any changes in circumstances that positively or negatively affect the financial plan and the implementation of the ERP's first ERPA during 2020

The Government of Guatemala (GoG) will facilitate the management of around 75 percent of the ERP's total investment cost resources, which add up to approximately USD 226 million. This contribution includes resources for coordination, monitoring, evaluations, reports, through underlying government programs, that is, INAB incentives through PROBOSQUE, PINPEP and CONAP's Program for the restoration, protection, and conservation of protected areas and biological diversity, the National REDD+ Strategy, among others of a similar nature.

The ERPD also indicates that the specific actions to be implemented in the ERP would be reinforced through interventions such as the Forest Investment Program (FIP), through an amount of USD 24 million, of which USD 3,150,000.00 correspond to a donation and USD 20,850,000.00 correspond to a loan. As of the date of presentation of this report, the Sustainable Forest Management Project is in negotiation process and the Green Guarantee for Competitive Landscapes Project is under implementation.

Therefore, the GoG, through Decree number 20-2020, Article 5, states that MAGA must prioritize with its own budget the additional allocation of five million quetzales (5,000,000.00) to INAB for the implementation and execution of the Program. To date, said budget allocation has not been made effective. However, INAB, in its capacity as Executing Unit, has financed with its own resources and those from cooperation for the establishment of the Executing Unit to begin the implementation of the Emission Reduction Program (ERP).

1.2 Update on major drivers and lessons learned

In 2019 as a part of the National REDD+ Strategy (2020-2050)[5] update, the main drivers of deforestation were determined as[6]:

1) Unsustainable use of forest products
2) Extension of livestock activity
3) Extension of agricultural activity

The unsustainable use of forest products is responsible for the loss of 39% of forest land with losses of 146,300 ha. For its part, the expansion of livestock activity accounts for 34% of the loss of forests and the expansion of agricultural activity causes losses of 24% of forests at the national level. The expansion of urban and industrial infrastructure generates only 1% of forest loss, while 2% of forest loss is due to other causes such as natural events (landslides, eruptions, pyroclastic material emissions, rock outcrops and others).

There are also drivers of forest degradation, including:

1) Unsustainable use of forest products
2) Forest fires

For the period 2006-2016, about 154,000 ha of forest land were degraded by the unsustainable use of forest products throughout the country, while 13,300 ha of the degraded area is associated with forest fires (southern and northern areas of the country).

Below is a brief description of the lessons learned on the causes of deforestation and forest degradation in Guatemala, compiled in the National REDD+ Strategy (2020-2050)[7].

- **Strengthening of local governance: For a greater application of the framework of Forestry policies in territorial spaces in which different normative instruments are applied, the integration of the forestry sector should be sought for the sustainable management of the territory, starting with the implementation of municipal development plans through participatory, inclusive and democratic processes.**

- **Operational strengthening of institutions related to agricultural, forestry and natural resource conservation activities (MARN, INAB, CONAP, MAGA) and municipalities:** For a better performance of the governing institutions of the forestry sector in reducing deforestation and forest degradation, it is important to continue with inter-institutional coordination mechanisms at both the central and municipal levels. In addition, the strengthening of local governments through the local institutional decentralization policy must be implemented effectively.

- **Increase budget investment and other resources to strengthen Forest management and control:** To strengthen institutional presence and that of government authorities for the supervision and control of land use change, a larger budget should be taken into account to increase the adequate human resource to be able to create innovative technical and legal conditions that generate new economic, social and technological mechanisms that allow reducing deforestation and forest degradation.

- **Strengthen the REDD+ Monitoring System:** The monitoring, reporting and verification (MRV) of emissions associated with deforestation and forest degradation agents is essential for the Guatemalan Government, in order to generate an adequate follow-up of the challenges it faces. Therefore, the ENREDD+ action plan foresees that, with a national budget complemented by international financing, gaps can be closed to strengthen

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[5] https://www.marn.gob.gt/wpfd_file/estrategia-nacional-redd/

[6] The information about drivers of deforestation differs from the ERPD, because updated information was used for this report.

[7] https://www.marn.gob.gt/wpfd_file/estrategia-nacional-redd/

detection systems and early warnings of illegal activities within and outside protected areas through satellite monitoring and potential hiring of trained staff.

- **Strengthen training, awareness, and communication systems:** To reduce deforestation and forest degradation, it is important to apply awareness, communication, and dissemination programs for national mechanisms, such as the management models of the Guatemalan System of Protected Areas and incentives for forests and plantations.

2 SYSTEM FOR MEASUREMENT, MONITORING AND REPORTING EMISSIONS AND REMOVALS OCCURRING WITHIN THE MONITORING PERIOD

2.1 Forest Monitoring System

Organizational structure

The MRV system of the forest sector has been built according to the capacities in the country to respond to the UNFCCC from the international point of view, and at the national level based on existing platforms, studies, data and processes, taking into account a diversity of governmental and non-governmental institutions, including academia, research centers and civil society organizations. In addition, it is based on the current legal frameworks: Forestry Law (Decree 101-96)[8], Law of Protected Areas (Decree 4-89)[9], and the Framework Law to Regulate the Reduction of Vulnerability, the Mandatory Adaptation to the Effects of Climate Change and Greenhouse Gas Mitigation (Decree 7-2013)[10]. These laws mandate the different government institutions to collect and process information according to their scope of action.

The MRV system for the Emission Reduction Program has been implemented through coordination by INAB, as the Executing Unit of the Program, with the support of technical staff from the GIS units and the climate change units/departments/ directorates of the institutions that make up CONAP, INAB, MARN and MAGA, as well as representatives of the Guatecarbon, Forests for Life and Local Networks (REDDES) REDD+ projects. The preparation of this report was complemented with the support of specialists from U*niversidad del Valle de Guatemala* [11]for carbon accounting.

All the information generated by the different institutions was integrated and systematized by INAB within the framework of the ERPA of the ER Program under the FCPF. In this sense, INAB has been an integrating unit and generator of the reports before the FCPF. It is in close coordination with MARN, as focal point before the UNFCCC, to ensure consistency between the information generated in the framework of the ERP and what is reported for other initiatives and commitments under the United Nations Framework Convention on Climate Change (UNFCCC), including GHG inventories for the LULUCF sector.

It is important to point out that each government institution of the Interinstitutional Coordination Group GCI[12] for the preparation of the First Emissions Reduction Monitoring Report has provided different inputs according to their competencies. A brief description of them is made in Table 1 below.

Table 1. Participating institutions in the elaboration of the First Emissions Reduction Monitoring Report and the inputs provided.

Institution	Inputs

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[8] https://www.inab.gob.gt/images/informacionpublica/2019/1.4.a%20Compendio%20de%20leyes%20y%20reglamentos%20forestales.pdf

[9] http://138.117.140.116/Documentos/ley.pdf

[10] https://faolex.fao.org/docs/pdf/gua140260.pdf

[11] Second monitoring report will be supported by UVG and a capacity building process will take place during 2023 for INAB to be full responsible of implementing the third MR with support from other institutions.

[12] GCI is the institutional governance body for REDD+ implementation in Guatemala.

INAB / Emission Reduction Program Executing Entity (Coordinatior, Technical coordinatior, departments of GIS and Climate change)	Coordinate ER monitoring report integration
	Forest Cover Maps (in collaboration with CONAP).
	National Forest Inventory.
	List with information and maps/polygons on the areas subject to incentives by PINPEP, PINFOR, and PROBOSQUE.
	Data, maps and/or polygons linked to the use of firewood and legal and illegal selective logging.
	Estimation of average annual increments (AAI), and removals due to increased carbon stocks at the national level, through forest management and reforestation (management of natural forests, plantations, AFSs, forestry incentives) and natural regeneration.
	Emission factors for degradation and Removal factors for increases in carbon stocks.
	Participate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.
CONAP / Climate Change Unit and the Geospatial Analysis Directorate, Center for Evaluation and Monitoring (CEMEC) located in Petén.	Forest Cover Maps (in collaboration with INAB) Forest fires data Participate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.?
MAGA / Geographic, Strategic Information and Risk Management and Climate Change Unit.	Develop anciliary datta such as vegetation cover and land use maps, for a potential estimate of carbon in the land uses. Suppor monitoring report integration.
MARN / Science and Metrics Department and the Mitigation Department of the Climate Change Unit, as well as in the Environmental Information and Climate Change Unit.	Reference Level of National Emissions for the Forest Sector and other land uses.
	Staff to standardize and ensure that there is consistency in the data presented in the ERP before the FCPF, the Greenhouse Gas Inventories (GHGIs), the reference level presented to the UNFCCC and the Registry of Projects for the Removal or Reduction of Greenhouse Gas (GHG) Emissions. Coordinate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.
REDD+ Projects Guatecarbon, Forests for Life, Networks for Local Development (REDDES)	Technical staff
	Data from REDD+ projects, polygon activities, etc.
	Community monitoring data.
	Relevant scientific studies and research.
	Complaints linked to drivers of deforestation and forest degradation.
Universidad del Valle de Guatemala	Support on carbon accounting, data processing. Support on visual interpretation of sample units of the national grid for generating LULUC Activity Data. Support on ER monitoring reor development.

	Support on uncertainty and sensitivity analisys.

2.1.2 Selection and management of GHG related data and information

Data selection and management was done to maintain consistency with the FREL included in the ERPD[13], and with the national FREL presented to UNFCCC[14]. This process was done by the GCI taking into consideration to use the best data available at the moment of generating the report which may also be available with the quality and in time to generate future reports. For the measurement and monitoring of activity data it is based on statistical sampling geo referencing of the territory using high and medium resolution sensors for the monitoring of forest cover, land use and land use change (LULUCF).

This approach is done by visual interpretation of samples, is easy to update for each monitoring period. Emission Factors are based on carbon strata map[15] which has been developed with the systematization and analysis of the best national data on carbon in the aerial and underground biomass of forests, from forest inventories in the country with different purposes and the first cycle of the National Forest Inventory of Guatemala, with the application of allometric models suitable for the country and its relationship with its bioclimatic variables.

The absorption factors (FA) are those estimated for the increase in carbon stocks by the annual growth of forest masses. They are obtained from the parcel system permanent sampling (PPM) established in the forestry incentive programs, with growth models applied to different species (pine and broadleaf).

2.1.2 Processes for collecting, processing, consolidating and reporting GHG data and information

The process of MRV in the ERP is implemented following the IPCC general equation of using Emission and Absorption Factors (related to forest inventory data) combined with Activity Data (related to remote sensing data) to estimate emissions and absorptions. A general approach of MRv in Guatemala is summarized in Figure 1.

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[13] https://www.forestcarbonpartnership.org/system/files/documents/guatemala_erpd_11_05_2019.pdf

[14] https://redd.unfccc.int/files/niveles_referencia_emisiones_forestales_guatemala_070222.pdf

[15] https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

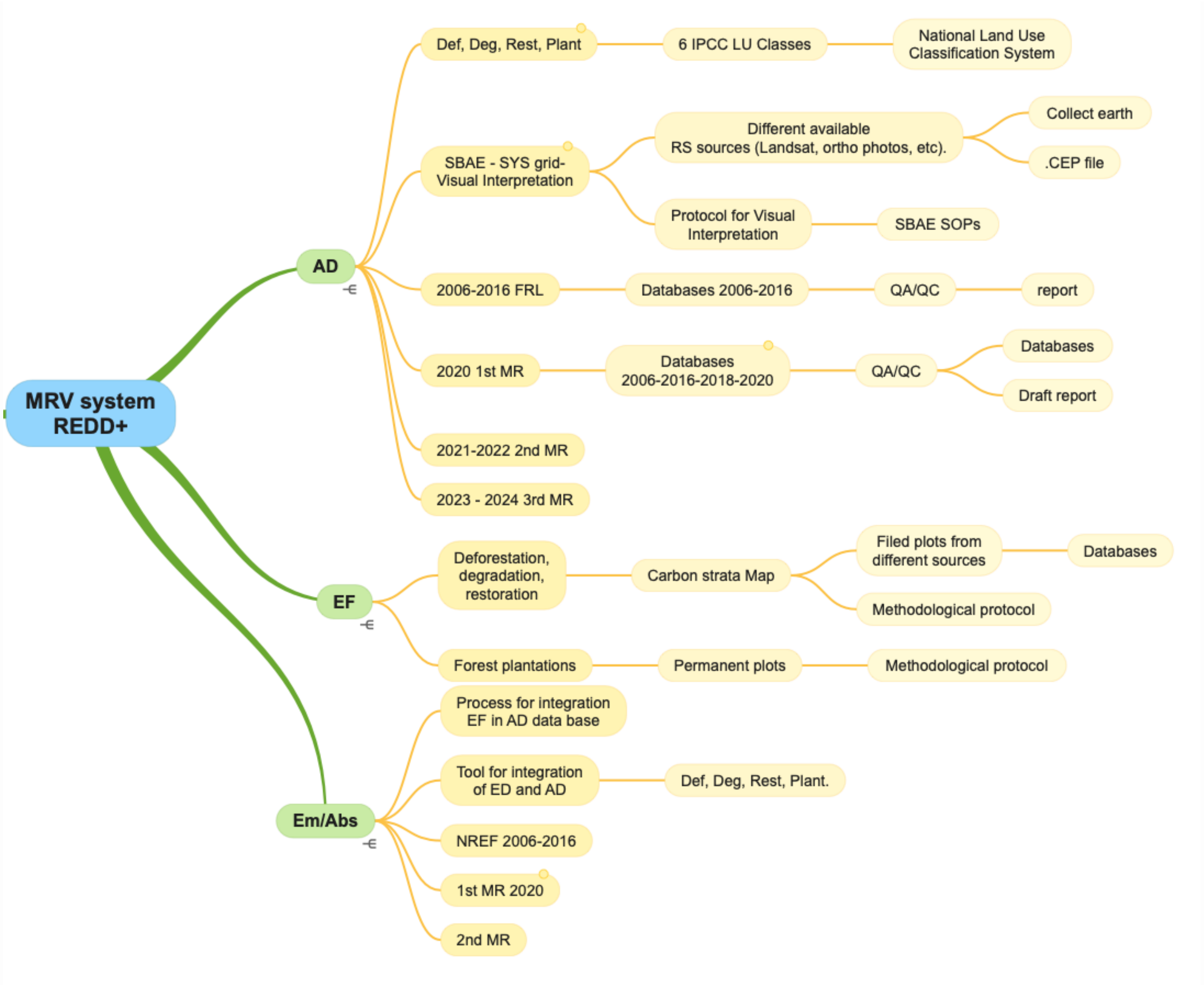

Figure 1 General approach for MRV for REDD+ in Guatemala ERP

2.1.2. Activity Data (AD)

For the collection of activity data under the ERPA, the land use categories of the Intergovernmental Panel on Climate Change (IPCC) were used for the assignment of land cover for each of the plots.

Activity data for reporting emission reductions in deforestation, degradation and carbon stock increases were monitored under the ERPA, reported using data generated using a Sample Based Área estimation through the use of a visually interpreted grid of sampling points developed with the Collect Earth platform[16] and using images available in high resolution (Digital globe, Planet, Aster, Sentinel, etc.), as well as medium resolution Landsat images (Table 2). This grid represents a geo-referenced statistical sampling of the territory and corresponds to a comprehensive approach to multi-temporal monitoring of forests and other land uses, which provides, during the ERP period, a specific and geographically-explicit analysis of the changes in the surfaces due to processes of deforestation, degradation and stock increases. Its use ensures consistency with the Forest Reference Emission Level (FREL). Currently, the grid activity data is generated every two years and the monitoring sample is 10,414 points, corresponding to the subnational area of the FCPF program.

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[16] https://openforis.org/tools/collect-earth/
Access to the Guatemalan information collection form:
https://drive.google.com/drive/folders/1IhxjFz5gPGKg-qCbXXBwU9cDOSnQ0E5m?usp=drive_link

These new activity data generated with the Collect Earth Desktop tool will be used to generate the next GHG Greenhouse Gas Inventories that will be contained within the Biennial Reports and the new National Communications that will be generated in the future, the previous four GHG Inventories GHG Greenhouse Gases that have been generated in Guatemala were prepared with methodologies other than sampling.

The grid is part of a comprehensive monitoring system for forests and other land uses, since it is complemented with the maps generated every five years to improve the cartographic model and increase its thematic accuracy and change detection (reduces uncertainty) to provide national statistics and international reports. See Table 2 and **Error! Reference source not found.**.

Table 2. *Main activity data inputs of the MRV System for deforestation, degradation and increases.*

Inputs	Type of Information	Scale/Resolution/Sampling Unit	Frequency	Source/Protocols
Point sampling grid for forest monitoring	Geodatabase with variables of forest cover and land use dynamics	National grid of 3.1 X 3.1 km for visual interpretation in medium and high resolution images (11,369 sampling points) for the entire country, regarding the FCPF program area, the total points correspond to a total of 10,414.	Multi-temporal evaluation of coverage and change of use every 2 years	GIMBUT, 2018
RS images	Collection of remote sensing images (DigitalGlobe, Airbus, INEG, AfriGIS, CNES)	Median: 30 m (Landsat, 5,7 and 8) High: 1.24 m to 5 m (Spot, WorldView, Rapid eye, Quick Bird, Sentinel, etc.)	Period of 15 days, Monthly, Annual	Google Earth, Engine and Bing Maps with the use of the Collect Earth platform (FAO, 2015)

2.1.2.2 Emission/Absorption Factors (EF/AF)

Regarding emission factors, the same ones used in the FREL were used. These are based on the carbon strata map, which presents the best national data on biomass carbon in forests, as a result of a systematization and analysis of forest inventories for different purposes, allometric models and bioclimatic variables, combined with national and default (IPCC) values on the non forest strata.

The absorption factors used for the MRV are the same ones used for the increases in carbon stocks that come from permanent sites in forest plantations of forestry incentive programs (INAB) with growth models for different species and that are used for the estimation of emissions in areas where a change from other lands to forest lands due to a plantation is detected. The main inputs for the emission and absorption factors of the MRV system and their characteristics are described in Table 3.

Table 3. Main inputs of emission and absorption factors of the MRV System for deforestation, degradation and increases.

	Inputs	Type of Information	Scale/Resolution/Sampling Unit	Source/Protocols
Emission Factors	Carbon Strata Map	Raster and Vector Geodatabases	1 ha	GIMBUT, 2017; Gómez Xutuc 2017.
	Carbon density of land use in agriculture, livestock use and agroforestry systems	Databases and estimation process in the Quantification of carbon. Specific studies.	Districts of crop producers and agroforestry systems	ANACAFÉ 1998, Castillo 2006
	Non-forest carbon contents	Default emission factors	National/ By type of climatic region	IPCC, 2006; IPCC, 2019
Absorption Factors	Permanent plots	Databases	Plots in forest plantations	INAB, 2012. Samudio 2017.
	Growth models	Average annual increments and absorption factors	National (forest plantations)	INAB, 2012. Samudio 2017.

It is important to mention that the carbon strata map has the limitation of not being dynamic and depending on the availability of updating new forest measurement plots or remeasurements of the analyzed plots, which makes its long-term use very complex. Therefore, it is important to make a substantial improvement in the MRV for emission and removal factors in the medium term[17]. For this, a National Forest Inventory for multiple purposes has already been launched, where a network of 715 sites has been established where variables related to the carbon content of biomass above ground, below ground and of dead organic matter, with a design of three secondary sampling units will be collected.

Regarding the monitoring report, the Working Group for the Preparation of the First ER Report of Guatemala processes the information and results of the estimates resulting from the analysis of the activity data and emission factors during the period of the ER Program and, then, subsequently transfers them to INAB so that it prepares the report to the FCPF (Figure 2). In turn, INAB transfers them to MARN for the report to the UNFCCC. It is important to mention that the diagram was created based on the structure that the executing unit has described in the operational process manual.

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[17] Not to be implemented during the ERP period.

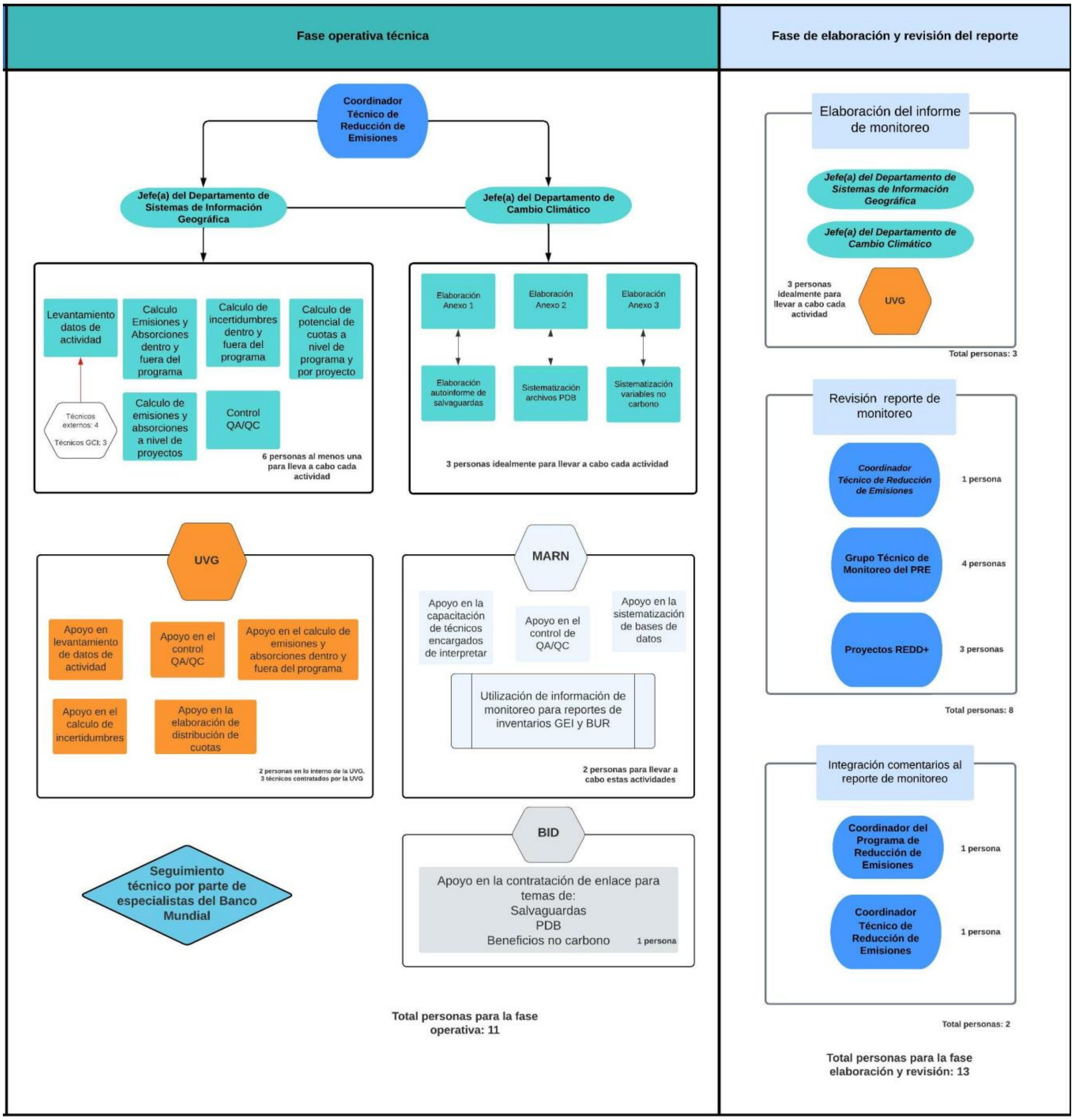

Figure 2. Process for the elaboration of the monitoring, validation and reporting report

The following (see

Table 4) summarizes the parameters and operations related to activity data and emission factors associated with the Guatemalan MRV System.

Table 4. Summary of parameters and operations of the MRV system.

Parameter	• AD: Area (ha) where deforestation, degradation, restoration of degraded forest areas or forest plantations occur. • EF: Carbon content and change in carbon content for each stratum of the carbon map or type of plantation. Default non-forest carbon content from IPCC guidelines. For agroforestry systems, national information is available. • Emissions and reductions of GHG emissions due to deforestation, degradation, restoration of degraded forest areas and increases in carbon stocks.
Description	• Analysis and interpretation of 10,414 grid points to identify areas with deforestation and degradation, as well as the restoration of degraded forest areas or forest plantations. All points at national scale will be monitored to ensure that there are no leaks to areas outside the program. • Use of EF data reported in Annex 4. • Monitoring and reporting of CO2 emissions and reductions due to deforestation and degradation separately for each activity, as well as emission reductions due to increases in carbon stocks in forest plantations and restoration of degraded forest areas.
Data Units	Ha, tC, tC/ha/year, tCO_{2eq}, $t\ CO_{2eq}$/year
Source of data or measurement/ calculation methods and procedures to be applied (e.g. field measurements, remote sensing data, national data, official statistics, IPCC Guidelines, commercial and scientific literature), including the spatial level of the data (local, regional, national and international) and if and how the data or methods will be approved during the Term of the ERPA.	• For the AD, data at the subnational level from the grid was used derived from visual interpretation of remote sensors to estimate activity data. • For EFs related to forest land, field data derived from the carbon strata map are used, which integrate forest inventory plots, permanent sites, and scientific research data. And national and default tabular values for forest plantations and non forest land uses. • The IPCC 2006 guidelines are followed for data processing.
Frequency of monitoring/ recording:	• For deforestation, 2016, 2018 and 2020 are monitored and for degradation 2016-2020, for future monitoring reports a frequency of two years (2021-2020, and 2023-2024) will be used.

Monitoring Equipment:	• For AD, data from different remote sensors of medium and high resolution, computer equipment, specialized software for processing satellite images and for surveying the sampling grid are used. • For the EF, forest inventory equipment, computer equipment and statistical software are used. Default non-forest carbon content from IPCC guidelines. • For the estimation of emissions, databases in Excel and statistical software are used.
Quality Assurance/ Quality Control procedures to be applied:	• Review of logical errors in the changes of the images interpreted for the dynamics of deforestation, degradation and increases in activity data. • Multiple interpretation (3 different interpreters) of a percentage of total sample plots where implemented and available to be analyzed. • All processes are described in different methodological protocols including procedures to ensure QA/QC processes as described in section 2.2.1. • Work is being done to use current protocols and refine them and translate in standard operating procedures format (SOP). • In addition, interpreters are trained prior to using the CE form in order to standardize interpretation criteria for the different land uses.
Identification of sources of uncertainty for this parameter	• Errors of interpretation of the categories. • Sample size for the analysis of the dynamics of change (deforestation, degradation and increases). • Quality of images available and used for interpretation. • Plot sampling errors. • Lack of representation of all types of forest vegetation in the carbon estimation plots available to build the carbon strata map (e.g. Dry forests). • Lack of information on estimated carbon content at the national level for most types of land use after conversion (crops, grasslands and agroforestry systems).
Process for managing and reducing uncertainty associated with this parameter	• AD: Integrate the same team of point grid interpreters so that there is consistency in the definition of land use. • EF: Group the types of land use that have the same carbon content to reduce the uncertainty of the emission factors associated with them.

2.1.3 Role of users, beneficiaries and communities in forest monitoring system

Forest community monitoring in the country during the year 2020 due to COVID-19 has been constituted from the local perspective in the primary source of information on the state of the forest, the natural resources associated with the ecosystem and the social and economic conditions of the communities directly and indirectly linked to the use and exploitation of these resources.

The Government of Guatemala has worked on the construction of a computer tool that is part of an early warning system for the prevention and control of deforestation and forest degradation. This tool was developed in the MRV of the National Climate Change System of Information (*SNICC, for its acronym in Spanish*) and also in a mobile application for smartphones aimed at providing information in the field to different users with and without Internet access. The development of this tool also seeks to support the operationalization of this system through the participation of local governments under the operational scheme of community monitoring of the country's National REDD+ Strategy. This information is available at the following link:
https://snicc.marn.gob.gt/MRV/SNMF

The community forest monitoring system contributes to the monitoring of social and environmental safeguards and the implementation of actions developed locally in the program. However, it does not participate in the monitoring of carbon variables. Below is a brief description of the role of community monitoring in 2020 in the different REDD+ Projects:

1. **Guatecarbon**: Through a community monitoring network made up of commissions for the control and protection of forest fires and a scientific commission on biodiversity, they have carried out monitoring of environmental and social issues in 11 communities of the Maya Biosphere Reserve, with a scope of at least 6,000 direct beneficiaries of the ERP.

2. **Forests for Life:** Through local workshops through community monitoring in the Sierra Lacandón Park, where the environmental and social issues of the ERP have been monitored, in at least three local communities and 120 direct beneficiaries of the program.

3. **Local Networks for Development (REDDES):** Actions were implemented to support the reduction of deforestation, degradation and increase of forest cover in 12 municipalities of the departments of Alta Verapaz, Quiché and Huehuetenango, to ensure the environmental goods and services that forests provide to indigenous communities and local organizations. These monitoring actions were carried out in at least 31 communities.

Community monitoring in the program is a process that is constantly being improved, since the participation of the local community has not yet been fully achieved. This is something that the government will work on in conjunction with the REDD+ Projects, to ensure that all activities are standardized and documented for the beneficiary communities. The Guatemalan MRV System will continue with the dynamic of empowering communities to gradually measure, monitor and report carbon stocks and, at the same time, that these activities contribute to local livelihoods and the conservation of forest biodiversity.

2.1.2 Coherence with the LULUCF sector monitoring system and the country's Climate Change MRV System

The MRV system within the framework of the ERP before the FCPF is part of the National Information System for GHG Emissions, Multiple Benefits, Other Impacts, Management and REDD+ Safeguards (*SIREDD+, for its acronym in Spanish*), which represents the institutional proposal within the framework of the National REDD+ Strategy for Guatemala (2020-2050). SIREDD+, in turn, is part of the National GHG Inventory System (*SNIGT, for its acronym in Spanish*), which is part of the SNICC (See Figure 4).

The SNICC aims to collect, systematize, analyze and present all the information related to climate change at the national level, including: Climate science, vulnerability, loss and damage; adaptation to climate change;

GHG emissions and removals; and, mitigation measures. This information may be used for sectoral and territorial planning processes, monitoring, and reporting of the country's progress, public investment programming and the formulation of public policies and application instruments on climate change. Therefore, the SNICC represents the set of data and information generated and analyzed, the necessary governance for the generation, analysis and reporting of this information and the virtual platforms that display it and make it public for the different users (Draft 1IBA, 2022).

1. All the country's climate change monitoring systems are incorporated under the SNICC, so that the organization and quality of the information can be ensured. Since monitoring related to REDD+ is part of this structure, consistency is ensured both with the country's LULUCF sector monitoring system and with the entire national climate change monitoring scheme, including the Registry of Projects for the Removal or Reduction of Greenhouse Gas (GHG) Emissions (Figure 3). The ERP's MRV System before the FCPF is included in this diagram under the REDD+ component, both in the carbon and safeguards sections.

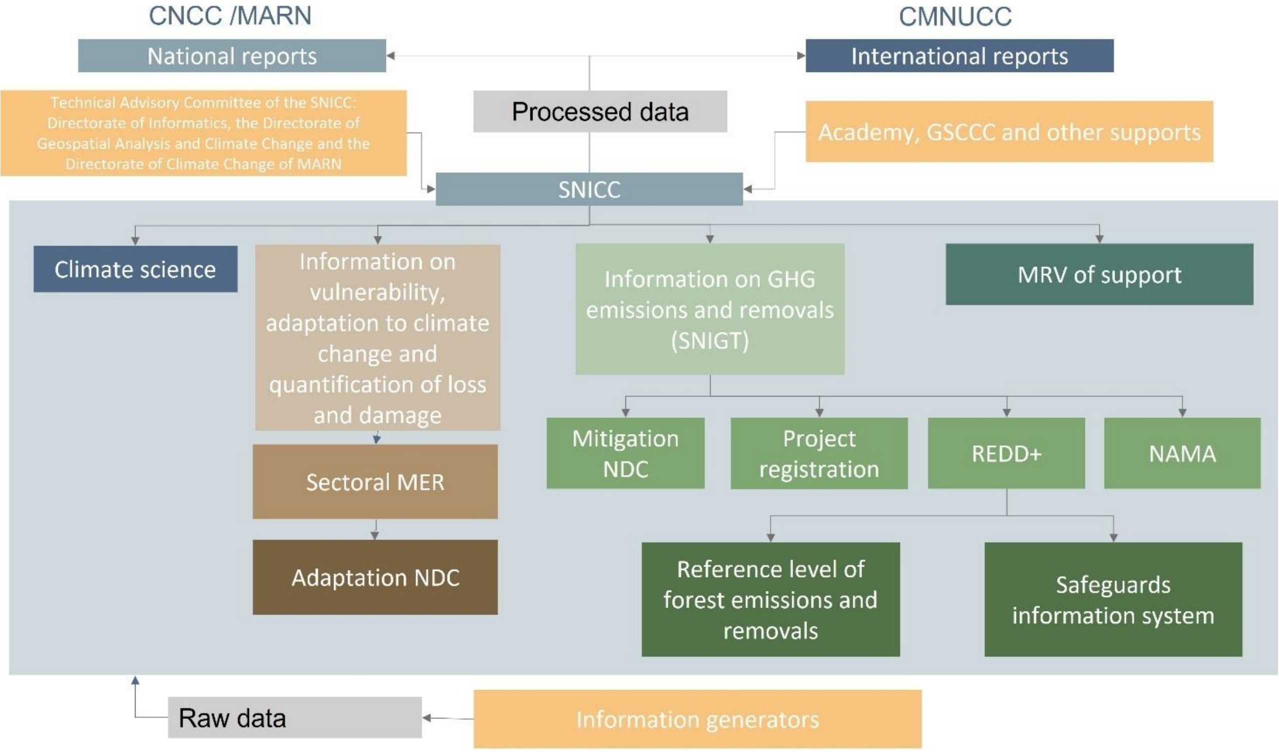

Figure 3. Operation and subsystems of the SNICC

2.1.5 Main changes with respect to what was presented in the ERPD

For this first monitoring event, some changes were made in relation to what was stated in the ERPD. One of the main changes is that it was agreed that INAB will be the entity in charge of the Executing Unit. This institution will therefore be in charge of submitting the monitoring report to the FCPF.

Likewise, for the analysis of forest degradation, it was not possible to differentiate the source causing the degradation, whether due to firewood, wood extraction or forest fires. In addition, it had been contemplated to use data from the National Forest Inventory (NFI) for the generation of activity data and emission factors, but since this is still in the data collection stage, they were not used for this first monitoring event.

Regarding the governance of the MRV system, the ERPD mentioned the participation of the Inter-institutional Group for Forestry and Land Use Monitoring (*GIMBUT, for its acronym in Spanish*). However, the agreement that gives validity to this entity expired in 2020. Therefore, this figure has been replaced by that of the Working Group for the Preparation of the First ER Report of Guatemala, which is made up of representatives of the GIS and climate change units of the GCI institutions.

In addition to the above, the country has already defined an MRV System scheme for the issue of climate change, so the REDD+ MRV System is now linked to the rest of the climate change monitoring systems at the national level, including the Registry of Projects for the Removal or Reduction of Greenhouse Gas (GHG) Emissions, for which the country already has the corresponding regulations (Ministerial Agreement 284-2020[18]) according to the mandate of Article 22 of the Framework Law to Regulate the Reduction of Vulnerability, Mandatory Adaptation to the Effects of Climate Change and Greenhouse Gas Mitigation. This allows coherence and consistency between the different processes and, therefore, in the data presented.

2.2 Measurement, monitoring and reporting approach

2.2.1. Line Diagram

The following diagram (Figure 4) shows the different components of the MRV System of the emission reduction program under the FCPF, where the main activities related to the generation of activity data, the estimation of emission/removal factors and the calculation of emissions and removals to obtain the emission reductions for the year of interest are presented. This line diagram is complemented by Figure 3, which details those responsible for the preparation of carbon accounting, safeguards, benefit sharing plan and non-carbon variables. The line diagram shows the step by step (seven steps in total) of each of the steps that are needed to have as a final result the emission reductions for the monitoring period.

For the process of calculating emissions reductions, the line diagram is intended to show the different processes from the generation of activity data, the allocation of carbon content, obtaining the emission and removal factors to obtain the emissions and removals of the reference level and the first monitoring. These processes are in charge of the head of the Geographic Information Systems unit of INAB with technical support from UVG.

Each step of the line diagram is described below:

- Step 1 Simple Base Area Estimation:

Consists of the use of the collect earth tool which allows us to use the high resolution images available in the Google Earth catalog. The tool also has external support to consult Planet, Sentinel and Landsat images, as well as to consult vegetation indexes. The document can be accessed:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

- Step 2 Visual interpretation of the CEP form:

In this step the visual interpretation of the 11,369 plots that are randomly distributed in Guatemala is performed. The collect earth form allows to establish the coverage and use for the current year, as well as to establish the coverage of the previous year. It also assigns whether the plot is a permanence or change in use, in addition to recording the date of the images used. The database is then exported and transformed from a comma-separated format to an Excel file. The form can be accessed through this link:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

CEP: https://drive.google.com/drive/folders/1IhxjFz5gPGKg-qCbXXBwU9cDOSnQ0E5m?usp=drive_link

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[18] http://www.snicc.marn.gob.gt/Content/PDF/Reglamento_Registro_de_Proyectos.pdf

- Intermediate step Prepare emission factors:

In this step we proceed to assign to each of the plots in Guatemala, the forest content stratum to the plots this with the objective of identifying the plots that had a change of use and to know the carbon content prior to deforestation or degradation.

The carbon layer map can be accessed through this link:
https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link
(Open with ArcGis)

The methodological protocol document can be accessed through this link:
https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

Step 3 Area estimation:
In this stage we proceed to calculate the hectares for each of the REDD+ activities that Guatemala reports, which are deforestation, degradation, carbon increments through the recovery of degradation and forest plantations. To estimate the area, the file "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" is used, and the data is found in column D for the reference level as for the first monitoring.

The document can be accessed through this link:
https://docs.google.com/spreadsheets/d/1IxckyzBxOS9hz7iGPR9IH58rLAf796Ju/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

- Step 4 Allocation of emission factors:

In this step the process that is done is to identify the transitions of all conversions that pertain to deforestation to identify which land use it is and thereby allocate the carbon contents pre and post deforestation.
In the case of degradation and recovery from degradation, the carbon stratum is identified in order to deduct 50% of the carbon initially held. To identify the emission factors from both forest and non-forest carbon content, use the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" and consult the column P, both for the reference level and the first monitoring.

The excel file can be consulted at the following link:
https://docs.google.com/spreadsheets/d/1IxckyzBxOS9hz7iGPR9IH58rLAf796Ju/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

- Step 5: Calculation of CO2/year per activity

In this step the process is to make the sum of the transitions associated with deforestation, degradation, increases in carbon by recovery of degradation and forest plantations. After the summation, the division is made in the corresponding years between the monitoring period or the reference level period. To identify the emissions from the identified activities, the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" can be used and the column AB can be consulted, both for the reference level and the first monitoring.

The excel file can be consulted at the following link:
https://docs.google.com/spreadsheets/d/1IxckyzBxOS9hz7iGPR9IH58rLAf796Ju/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

- Step 6 Calculation of emissions/removals:

The next step is to obtain the net emissions of the reference level period as the first monitoring period. To perform this calculation, the emissions from deforestation and degradation are added to the sum of the removals from carbon enhancements from restoration of degradation and forest plantations. This operation gives the net emissions, which can be positive, indicating emissions, and negative, indicating removals. To identify the emissions from the identified REDD+ activities, the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" can be used and consult the Summary tab, both for the reference level (Column C) and the first monitoring (Column D).

The excel file can be consulted at the following link:
https://docs.google.com/spreadsheets/d/1IxckyzBxOS9hz7iGPR9IH58rLAf796Ju/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

- Step 7 Emission reduction calculation:

This step is performed using the net emissions of the reference level period and subtracts them from the net emissions of the monitoring period to obtain the emission reductions. To identify the reductions from the identified REDD+ activities, use the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" and consult the Summary tab, and check column E.

The excel file can be consulted at the following link:
https://docs.google.com/spreadsheets/d/1IxckyzBxOS9hz7iGPR9IH58rLAf796Ju/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

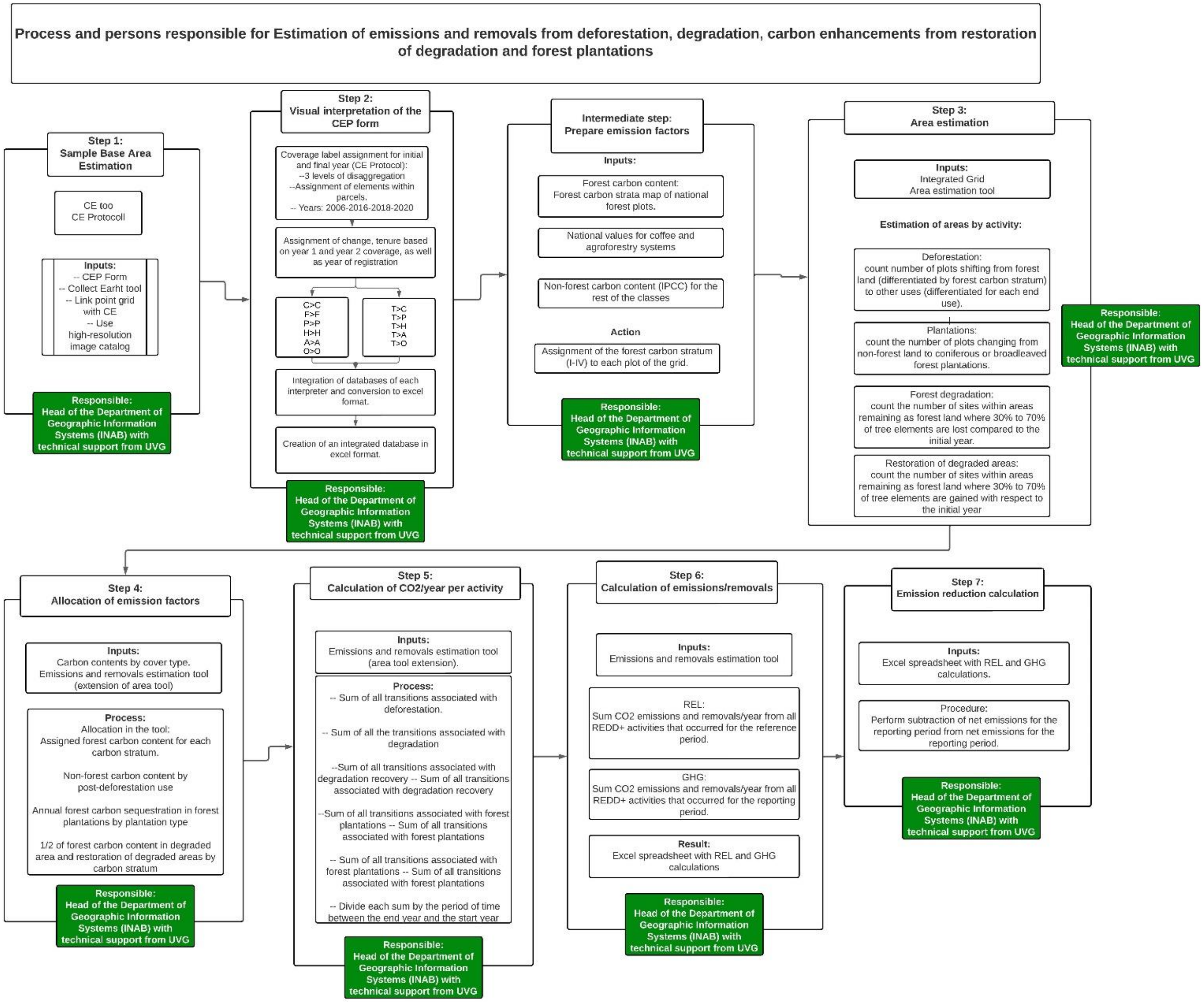


Figure 4. Components for calculating the program's emission reductions.

2.2.2 Calculation

1. Emission reduction (ER)

$$\mathbf{ER_{ERP}=RL_T-GHG_T} \qquad \text{Equation 1}$$

Where:

$\mathbf{ER_{ERP}}$	=	Emission Reductions under the ER Program in year t ($tCO_2e*year^{-1}$)
$\mathbf{RL_T}$	=	Gross emissions of the RL from deforestation over the Reference Period ($tCO_2e*year^{-1}$). Net annual average emissions of the RL due to deforestation and degradation and the absorptions due to the increases in carbon during the reference period(($tCO_2e*year^{-1}$) This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.
$\mathbf{GHG_T}$	=	Monitored gross emissions from deforestation at year t ($tCO_2e*year^{-1}$) Annual net emissions from deforestation and degradation and the absorptions due to increase in carbon in the reporting period ($tCO_2e*year^{-1}$)
T		Number of years during the monitoring period; dimensionless

2. Reference Level (RL)

The RL estimation may be found in Annex 4, yet a description of the equations is provided below. RL was defined as the net annual average historical emissions. Annual emissions or absorptions were estimated for all land transitions by REDD+ activity, and then adding the results for all selected REDD+ activities for each year.

The REDD+ activities that are included in the reference level for Guatemala are:

- Emissions from deforestation and forest degradation.
- Absorptions from increases in forest stock that may be due to recovery of forest degradation and forest plantations.

Equation 2:

$$\mathbf{RL=(Def+deg)-(Incr) = (E_{DEF}+E_{DEG}) - (R_{rec}+R_{pla}) = ((ADef * FE) + (ADdeg * FE) - (Rrec * FA) - (Rpla * FA))}$$

Where:

$\mathbf{RL}$ = Reference Level
$\mathbf{E_{DEF}}$ = Emissions from Deforestation
$\mathbf{E_{DEG}}$ = Emissions from Degradation
$\mathbf{R_{rec}}$ = Removals from Forest Degradation Recovery
$\mathbf{R_{pla}}$ = Removals due to Increased Carbon Through Forest Plantations
AD = Activity data for conversion of forest lands to other lands (Deforestation), permanent forest lands with forest cover loss (Degradation),and degraded permanent forest lands that increase their forest cover and establishment of forest plantations (Increases).
FE = Emission factors for deforestation and degradation and
FA = Absorption factors for carbon increases in forest biomass.

To determine the emissions of the reference level, the first step is to calculate the information from the activity data and then make the estimate in tons of CO_2 equivalent.

Below you will find the links to the files to estimate the activity data, as well as the emissions and removals of the reference level.

- File containing the estimates of emissions and removals for each of the REDD+ activities:
- File that contains the information of the point grid with its categories of land use:

2.1. Reference level activity data

2.1.1. Activity Data of deforestation

To determine the activity data, a random mesh was used consisting of 11,369 plots for the entire country and 10,414 plots for the program area. Each plot has a total of 25 elements and the use is determined by the coverage that predominates.

Equation 3:

$$AD_{def}=\left(\frac{N_{def}}{N_{Total}}\right)*T$$

Where:

AD_{def} = Data derived from deforestation

N_{def} = Number of plots that were interpreted as deforestation in the period studied

N_{Total} = Total number of parcels found in the program area

T = Surface area of the program expressed in hectares

2.1.2. Activity data for degradation

Equation 4:

$$AD_{deg}=\left(\frac{N_{deg}}{N_{total}}\right)*T$$

Where:

AD_{deg} = Activity data derived from forest degradation

N_{deg} = Number of plots of forest remaining forest where forest cover loss is between 30-70%.

N_{total} = Total number of parcels found in the program area

T = Surface area of the program expressed in hectares

2.1.3. Forest degradation recovery activity data

Equation 5:

$$AD_{rec}=\left(\frac{N_{rec}}{N_{total}}\right)*T$$

Where:

AD_{rec} = Activity data derived from recovery from forest degradation

ND_{rec} = Number of plots of forest remaining forest where forest cover gain is between 30-70%

N_{total} = Total number of parcels found in the program area

T = Surface area of the program expressed in hectares

2.1.4. Increases for forest plantations

Equation 6:

$$AD_{pla} = \left(\frac{N_{pla}}{N_{total}}\right) * T$$

Where:

AD_{pla} = Activity data for reforestation through forest plantations

N_{pla} = Number of plots that goes from non forest lands to forest plantations

N_{total} = Total number of parcels found in the program area

T = Surface area of the program expressed in hectares

2.1.5. Activity data for forest land maintained as forest land

Equation 7:

$$AD_{f} = \left(\frac{N_{f}}{N_{total}}\right) * T$$

This formula is used to find out if the forest plots have undergone a degradation process or a degradation recovery process.

Where:

AD_{f} = Activity data for forest land maintained as forest land

N_{f} = Number of plots that are categorized as forest that remain as forest.

N_{total} = Total number of parcels found in the program area

T = Surface area of the program expressed in hectares

2.2. Reference level emission and removal data

2.2.1. Emissions from Deforestation

Equation 8:

$$\mathrm{Edef} = \sum_{\mathbf{j,i}} (\,(\mathrm{C_{for}} - \mathrm{C_{nofor}})\ \mathrm{x}\ \frac{44}{12} \times \mathrm{A(j,i)}\ \ )/RP$$

Where:

Edef = Emissions caused by deforestation (tCO2 per year)

$\underline{A}_{(j,i)RP}$ = Area from activity data that has been converted from forest type j to non-forest type i during the Reference Period, in hectares per year. In this case, Guatemala, the forests have a division based on four carbon strata:

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

Ten types of non-forest land are considered:

- Cropland (C): What are annual crops, African palm, rubber and coffee. What are annual crops, African palm, rubber and coffee.
- Agroforestry systems such as shade-grown coffee was separated.
- Grassland (P);
- Wetland (A);
- Settlement (U); and
- Other lands (O).

$\underline{C}_{for}$ = Total forest carbon content of each strata j before conversion/transition, in tons of carbon per ha.

$\underline{C}_{nofor}$ = Total non forest carbon content of each non-forest land use i after conversion, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

The conversions identified for the reference level for Guatemala are the following:

Forest to croplands

1. Forest I to cropland lands
2. Forest II to cropland lands
3. Forest III to cropland lands
4. Forest IV to cropland lands
5. Forest I to cropland-coffee lands
6. Forest II to cropland-coffee lands
7. Forest III to cropland-coffee grounds
8. Forest IV to cropland-coffee lands
9. Forest I to cropland lands-African palm
10. Forest II to cropland lands-African palm
11. Forest III to cropland fields-African palm
12. Forest IV to cropland lands-African palm
13. Forest I to cropland lands-rubber
14. Forest II to cropland-rubber lands
15. Forest III to cropland-rubber grounds
16. Forest IV to cropland-rubber lands

Forest to agroforestry systems

17. Forest I to agroforestry systems
18. Forest II to agroforestry systems
19. Forest III to agroforestry systems
20. Forest IV to agroforestry systems

Forest to grasslands

21. Forest I to grasslands
22. Forest II to grasslands
23. Forest III to grasslands

24. Forest IV to grasslands

Forest to settlements

25. Forest I to settlements
26. Forest II to settlements
27. Forest III to settlements
28. Forest IV to settlements

Forest to other lands

29. Forest I to other lands
30. Forest II to other lands
31. Forest III to other lands
32. Forest IV to other lands

Forest to wetlands and bodies of water

33. Forest I to wetlands and bodies of water
34. Forest II to wetlands and bodies of water
35. Forest III to wetlands and water bodies
36. Forest IV to wetlands and water bodies

The following tables show the forest carbon content as well as the content of other non-forest land uses. The origin of each of the values is shown in more detail in Chapter 3.

Forest carbon content

Stratum	Forest carbon content – Cfor-- (Ton/ha)
Forest I	122.06
Forest II	101.73
Forest III	97.77
Forest IV	125.19

Non-forest carbon content

Non forest land Use	Non forest carbon content – Cnofor-- (Ton/ha)
Croplands (all classes not specified) and grasslands	4.7
Croplands-Coffee (intensive)	2.65
Grasslands	6.73
Croplands-African Palm	2.4
Croplands-Rubber	3
Agroforestry systems (shaded coffee)	20.1
Settlements	0
Wetlands	0
Other lands	0

2.2.2. Emissions from degradation

Equation 9:

$$Edeg = \sum_{\mathbf{j,i}} ((\mathrm{Cfor} - \mathrm{Cdeg})\ \mathrm{x}\ \frac{44}{12} \times \mathrm{A(j,i)}\ \ )/RP$$

Where:

Edeg = Emissions caused by forest degradation in hectares per year

$\underline{A}_{(j,i)RP}$ = Activity data area that has undergone a degradation process within the forest cover during the reference period, in hectares per year. In the case of Guatemala, the analysis of forest degradation was made for the four strata that Guatemala has.

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

<u>Cfor</u> = Total forest carbon content of each forest type j before conversion/transition, in tons of carbon per ha.

Cdeg = Forest carbon content of each degradated forest type j, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

2.2.3. Removals from forest degradation recovery

Equation 10:

$$Edeg = \sum_{\mathbf{j,i}} ((\mathrm{Cdeg} \quad - \mathrm{C_{for}})\,\mathrm{x}\,\frac{44}{12} \times \mathrm{A(j,i)} \quad)/RP$$

Where:

Rrec = Removals obtained from the recovery of forest degradation in hectares per year

$\underline{A}_{(j,i)RP}$ = Area that have had a recovery from degradation within the forest cover during the reference period, in hectares per year. In the case of Guatemala, the analysis of forest recovery degradation was made for the four strata that Guatemala has.

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

Cdeg = Forest carbon content of each degradated forest type j, in tons of carbon per ha.

Cfor = Total forest carbon content of each forest type j before conversion/transition, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

2.2.4. Removals due to increased carbon through forest plantations

Equation 11:

$$Rpla = \sum_{\mathbf{j,i}} ((AAI) \text{ x } \frac{44}{12} \times \mathrm{A(j,i)} \quad)/RP$$

Where:

Rpla = Removals obtained by the establishment of forest plantations in hectares per year

$\underline{A}_{(j,i)RP}$ = Area that has been identified as forest plantation. In the case of Guatemala, two types of plantations are managed:
- Broadleaf Plantation
- Conifer plantation

$\underline{\text{AAI}}$ = Average annual increase that was identified for each of the types of forest plantations, in this case:
- Broadleaf plantations
- Coniferous plantations

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

3. Reporting period (GHG)

Net emissions during the monitoring period in the accounting area are estimated by subtracting carbon emissions and carbon removals.

Equation 12:

GHG=(Def+deg)-(Incr) = $(\mathbf{E_{DEF}}+\mathbf{E_{DEG}})$ **-** $(\mathbf{R_{rec}}+\mathbf{R_{pla}})$ **=** $((\mathbf{ADdef} * \mathbf{FE}) + (\mathbf{ADdeg} * \mathbf{FE}) - (\mathbf{ADRrec} * \mathbf{FA}) - (\mathbf{ADRpla} * \mathbf{FA}))$

Where:

GHG = Reporting period
$\mathbf{E_{DEF}}$ = Emissions from Deforestation
$\mathbf{E_{DEG}}$ = Emissions from degradation
$\mathbf{R_{rec}}$ = Removals from forest degradation recovery
$\mathbf{R_{pla}}$ = Removals due to increased carbon through forest plantations
AD = Activity data for conversion of forest lands to other lands (Deforestation), permanent forest lands with forest cover loss (Degradation), other lands that become forest lands and degraded permanent forest lands that increase their forest cover and establishment of forest plantations (Increases).
FE = Emission factors for deforestation and degradation
FA = Absorption factors for carbon increases in forest biomass

The first step to calculate the net emissions of the monitoring period is the calculation of the activity data.

Activity data of the monitoring period

3.1. Activity Data of deforestation

To determine the activity data, a random mesh was used consisting of 11,369 plots for the entire country and 10,414 plots for the program area. Each plot has a total of 25 elements and the use is determined by the coverage that predominates.

Equation 13:

$$AD_{def}=\left(\frac{N_{def}}{N_{Total}}\right)*T$$

Where:

AD_{def} = Data derived from deforestation
N_{def} = Number of plots that were interpreted as deforestation in the period studied
N_{Total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

3.1.1. Activity data for degradation

Equation 14:

$$AD_{deg}=\left(\frac{N_{deg}}{N_{total}}\right)*T$$

Where:

AD_{deg} = Activity data derived from forest degradation
N_{deg} = Number of plots of forest remaining forest where forest cover loss is between 30-70%.
N_{total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

3.1.2. Forest degradation recovery activity data

Equation 15:

$$AD_{rec}=\left(\frac{N_{rec}}{N_{total}}\right)*T$$

Where:

AD_{rec} = Activity data derived from recovery from forest degradation
ND_{rec} = Number of plots of forest remaining forest where forest cover gain is between 30-70%.
N_{total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

3.1.3. Increases for forest plantations

Equation 16:

$$AD_{pla} = \left(\frac{N_{pla}}{N_{total}}\right) * T$$

Where:

AD_{pla} = Activity data for reforestation through forest plantations
N_{pla} = Number of plots that goes from other lands to forest plantations.
N_{total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

3.1.4. Activity data for forest land maintained as forest land

Equation 17:

$$AD_{f} = \left(\frac{N_{f}}{N_{total}}\right) * T$$

This formula is used to find out if the forest plots have undergone a degradation process or a degradation recovery process.

Where:

AD_{f} = Activity data for forest land maintained as forest land
N_{f} = Number of plots that are categorized as forest that remain as forest.
N_{total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

3.2. Monitoring period emission and removal data

Equation 18:

3.2.1. Emissions from Deforestation

$$\mathrm{Edef} = \sum_{\mathbf{j,i}} \left((\mathrm{C_{for}} - \mathrm{C_{nofor}}) \mathrm{\ x\ } \frac{44}{12} \times \mathrm{A(j,i)} \right) / RP$$

Where:

Edef = Emissions caused by deforestation in tCO2 per year.

$\underline{A}_{(j,i)RP}$ = Area from activity data that has been converted from forest type j to non-forest type i during the monitoring period, in hectares per year. In this case, Guatemala, the forests have a division based on four carbon strata:

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

Ten types of non-forest land are considered:

- Cropland (C): What are annual crops, African palm, rubber and coffee

- Agroforestry systems such as shade-grown coffee was separated.
- Grassland (P);
- Wetland (A);
- Settlement (U); and
- Other lands (O).

Cfor = Total carbon of each forest carbon content strata before conversion/transition, in tons of carbon per ha.

Cnofor = Total carbon of each non-forest content type i after conversion, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the monitoring period.

Forest to croplands

1. Forest I to cropland lands
2. Forest II to cropland lands
3. Forest III to cropland lands
4. Forest II to cropland lands-African palm

Forest to agroforestry systems

5. Forest I to agroforestry systems
6. Forest II to agroforestry systems
7. Forest III to agroforestry systems

Forest to grasslands

8. Forest I to grasslands
9. Forest II to grasslands
10. Forest III to grasslands
11. Forest IV to grasslands

Forest to settlements

12. Forest II to settlements

Forest to other lands

13. Forest II to other lands
14. Forest IV to other lands

Forest to wetlands and bodies of water

The following tables show the forest carbon content as well as the content of other non-forest land uses. The origin of each of the values is shown in more detail in Chapter 3.

Forest carbon content

Stratum	Forest carbon content – Cfor-- (Ton/ha)
Forest I	122.06
Forest II	101.73
Forest III	97.77
Forest IV	125.19

Non-forest carbon content

Non forest land Use	Non forest carbon content – Cnofor-- (Ton/ha)
Croplands (all classes not specified) and grasslands	4.7

Croplands-Coffee (intensive)	2.65
Grasslands	6.73
Croplands-African Palm	2.4
Croplands-Rubber	3
Agroforestry systems (shaded coffee)	20.1
Settlements	0
Wetlands	0
Other lands	0

3.2.2. Emissions from degradation

Equation 19:

$$\mathrm{Edeg} = \sum_{\mathbf{j,i}} \left(\left(\mathrm{C_{for}} - \mathrm{C_{deg}} \right) \mathrm{x}\ \frac{44}{12} \times \mathrm{A(j,i)} \right) / \mathrm{RP}$$

Where:

Edeg = Emissions caused by forest degradation in tCO2 per year.

$A_{(j,i)RP}$ = Activity data area that has undergone a degradation process within the forest cover during the monitoring period, in hectares per year. In the case of Guatemala, the analysis of forest degradation was made for the four strata that Guatemala has.

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

Cfor = Total carbon of each forest carbon content strata forest type j before conversion/transition, in tons of carbon per ha.

Cdeg = Half of total forest carbon content of each forest carbon content strata forest type j before conversion/transition, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the monitoring period.

3.2.3. Removals from forest degradation recovery

Equation 20:

$$Edeg = \sum_{\mathbf{j,i}} \left(\left(\mathrm{C_{deg}} - \mathrm{C_{for}} \right) \mathrm{x}\ \frac{44}{12} \times \mathrm{A(j,i)} \right) / RP$$

Where:

Rrec = Removals obtained from the recovery of forest degradation in tCO2 per year.

$A_{(j,i)RP}$ = Area that has had a recovery from degradation within the forest cover during the reference period, in hectares per year. In the case of Guatemala, the analysis of forest recovery degradation was made for the four strata that Guatemala has.
  - Stratum I
  - Stratum II
  - Stratum III
  - Stratum IV

Cdeg = Half of total carbon of each forest carbon content strata before conversion/transition, in tons of carbon per ha.

Cfor = Total forest carbon content of each forest type j before conversion/transition, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the monitoring period.

3.2.4. Removals due to increased carbon through forest plantations

Equation 21:

$$Rpla = \sum_{\mathbf{j,i}} ((AAI) \text{ x } \frac{44}{12} \times \mathrm{A(j,i)} \quad)/RP$$

Where:

Rpla = Removals obtained by the establishment of forest plantations in tCO2 per year.

$A_{(j,i)RP}$ = Area that has been identified as forest plantation. In the case of Guatemala, two types of plantations are managed:
  - Broadleaf Plantation
  - Conifer plantation

AAI = Average annual increase that was identified for each of the types of forest plantations, in this case:
  - Broadleaf plantations
  - Coniferous plantations

44/12 = Conversion of C to CO_2

RP = Years consisting of the monitoring period.

3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

Parameter:	Forest carbon content (Cfor)
Description:	Forest carbon content of four carbon strata before conversion to non-forest land Used in equations: 8,9,10,11 and 18,19,20,21.
Data unit:	Ton of carbon per hectare
Source of data or	The information generated in the carbon strata map of Guatemala was used to establish biomass above and below ground for forest information.

description of the method for developing the data including the spatial level of the data (local, regional, national, international):

To obtain the carbon content, a study was carried out in which a total of 2,036 forest plots were analyzed, which was prepared by the National Council of Protected Areas with the support of GIMBUT. For more details and explanation of how the value was obtained for the four strata of forest carbon in Guatemala you can consult the report that was made, which is in the following link:
https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

To obtain greater clarity on how the forest carbon content in Guatemala was constructed, the documents, databases and spatial data have been placed in the section of any comments.

The most significant pool includes above-ground biomass carbon from trees greater than 10 cm in diameter (Trees greater than 10 cm DBH[19] are included, because for Guatemala it is the definition of a tree). measured at 1.3 m (DBH).

The data of this pool is modeled in the carbon strata map at the national level, which was prepared from 2,306 plots of forest inventories, from different projects, which were systematized, refined, standardized, and analyzed to obtain the value of biomass for each individual greater than 10 cm DBH[20].

General allometric equations were applied, differentiating between broadleaf forests in Petén, coniferous forests, broadleaf forests and mangrove forests. In the latter, three species-specific equations were used. The factor 0.47 was used to convert biomass to carbon and the result per hectare was standardized by dividing the result by the plot size.

The second pool, which is related to the previous one, includes below-ground biomass (roots). To estimate below-ground biomass, an above-ground biomass ratio equation was used for all plots (Mokany, Raison & Prokushkin 2006), except for the Mangrove Forest plots, where an equation was used (Komiyama et al. 2008).

The following (see Table 5) shows the equations used to calculate the biomass above and below ground for the Petén, conifers, broadleaves and three mangrove species forests, which take into consideration the relationship in function of the proportion of aerial biomass for the below-ground biomass.

Table 5. Allometric equations used.

Species/Region	Equation	Source	r2	N	Dmax

---

[19] For Guatemala, the following definition for a tree is used:
Woody plant with a defined stem and crown with secondary growth that, when mature, reaches a minimum height of 5 meters and a minimum diameter of 10 cm. Bamboos and palms are excluded.

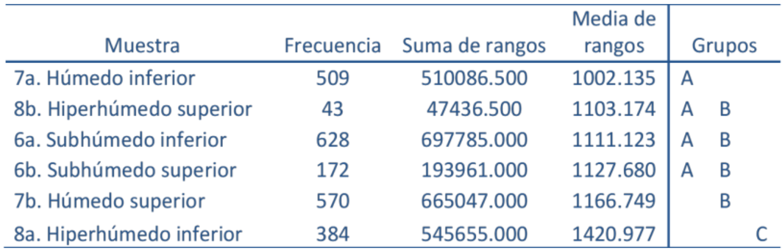
Rhizophora mangle L.	0.178*DBH^2.47	Imbert and Rollet	0.98	17	Unknown
Laguncularia racemosa (L.)	0.1023*DBH^2.50	Fromard et al.	0.97	70	10
Avicennia germinans (L.) L.	0.14*DBH^2.4	Fromard et al.	0.97	25-45	42.4
Conocarpus erectus L.	0.1023*DBH^2.50	Fromard et al.			
Petén	10^ (-4.09992+(2.57782*LOG10(DBH))) *1000	Arreaga 2002	95	139	130
Broadleaf	0.13647 * DBH^2.38351	UVG 2015	0.939	100	79.9
Conifers	0.15991 * DBH^2.32764	UVG2015	0.966	80	82

With the biomass data for each individual, the conversion of tons of biomass to carbon is made, multiplying by the fraction of 0.47 and the value for one hectare is extrapolated, according to the size of each plot. The values are added for each of the plots, and results in a standardized value of tons of carbon per ha in each of them.

Each plot has geographic location data, and these were stratified bioclimatically, as an indirect measure of primary productivity, based on the ombrothermal indices generated for Guatemala, which were constructed with data obtained from the World Clim digital page, using the monthly precipitation and temperature averages. This climatic classification has been widely used in Guatemala as a basis for regional planning and for the integration of other variables of interest to forest services or biological conservation (CONAP, 2015).

The plots with their carbon content were located in 6 ombric horizons, and data (the carbon content data of the analyzed plots) distribution tests were carried out for each of them, finding that none presented normality in the data distributions. Therefore, to carry out the stratification according to the ombric horizons, a comparison test of k samples (Kruskal-Wallis) was carried out, where statistically differentiated groups were detected as shown below (See Table 6).

Table 6. Grouping categories according to climatic regime.



Muestra	Frecuencia	Suma de rangos	Media de rangos	Grupos		
7a. Húmedo inferior	509	510086.500	1002.135	A		
8b. Hiperhúmedo superior	43	47436.500	1103.174	A	B	
6a. Subhúmedo inferior	628	697785.000	1111.123	A	B	
6b. Subhúmedo superior	172	193961.000	1127.680	A	B	
7b. Húmedo superior	570	665047.000	1166.749		B	
8a. Hiperhúmedo inferior	384	545655.000	1420.977			C

As shown below, from the statistical grouping, four strata were determined at the national level according to the amount of carbon and the zones of ombric horizons (See Table 7). The groups that are observed in table 8, indicate those ombric indices that are statistically related to each other. That is why the result is four groups.

Table 7. Groups in which climatic regimes are classified.

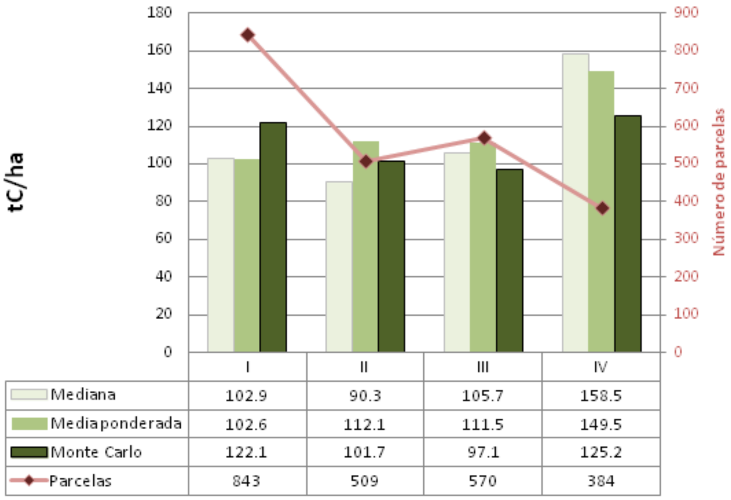
Ombric Horizon	Statistical grouping			Final Group
6a. Subhumid – Low	A	B		I
6b. Subhumid – High	A	B		I
7a. Humid – Low	A			II
7b. Humid – High		B		III
8a. Hyper Humid - Low			C	IV
8b. Hyper Humid - High	A	B		I

With these data, the values were assigned to those areas whose ombric horizon did not have enough plots to be represented (e.g. Dry type), leaving the final stratification as detailed in Table 8, with which the national coverage is achieved.

Table 8. Strata assigned to horizons with insufficient values.

Stratum	Ombric Type	Ombric Horizon
I	4. Semi-Arid	4b. Semi-Arid – High
	5. Dry	5a. Dry – Low
	5. Dry	5b. Dry – High
	6. Sub-Humid	6a. Sub-Humid Low
	6. Sub-Humid	6b. Sub-Humid High
II	7. Humid	7a. Humid – Low
III	7. Humid	7b. Humid - High
IV	8. Hyper-Humid	8a. Hyper-Humid - Low
I	8. Hyper-Humid	8b. Hyper-Humid - High
	9. Ulta Hyper-Humid	9. Ulta Hyper-Humid

In order to have more consistent data in the estimation of tons of carbon per hectare and per stratum, descriptive statistics were made for each group and the resulting carbon content ranges were compared. Due to the great variability of the data according to the size of the plots and sampling designs, calculations of carbon density were made with the median and the weighted mean was also calculated for the four strata according to the proposal of Thomas and Rennie, 1987, who define that variance is a good estimator of the mean. Due to the variability of sampling designs for different purposes, data distribution (non-normal) and plot sizes, the Monte Carlo method was used to estimate carbon in the cartographic model (carbon map) because it weights directly the size of the plot and identifies the probability density function (PDF) of the data by plot size and by stratum through goodness-of-fit tests (Gómez Xutuc, 2017). Once the PDFs have been identified, it performs simulations of the carbon content per hectare, obtaining a better estimator from their Probability Density Functions (PDFs) (Figure 6). Thus, 10,000 simulations were run, truncating distributions according to the minimum and maximum of each data (tC/ha) by plot size and by stratum, respectively. The median was used for the analysis, since these are data that do not present a normal distribution.



	I	II	III	IV
Mediana	102.9	90.3	105.7	158.5
Mediaponderada	102.6	112.1	111.5	149.5
Monte Carlo	122.1	101.7	97.1	125.2
Parcelas	843	509	570	384

Figure 5. Estimated values for the carbon map.

Value applied:

The final values of forest biomass above and below ground were as follows.

Table 9. Carbon values obtained for each stratum.

Strata	Median	Typical Deviation
I	122.06	0.187
II	101.73	0.553
III	97.11	0.459
IV	125.19	0.602

QA/QC procedures applied

Review and evaluation of atypical data for its depuration.

A bounded equation was made based on maximum and minimum carbon values. Poorly located plots that did not have a correct georeferencing location were purged located plots that did not have a correct georeferencing location were purged.

Additional analysis was done to check the accuracy of the map against the plots of the project inventories. Since the country also submitted a reference level to the United Nations Convention on Climate Change, we proceeded to review whether the correspondence of the map's carbon layers was in line with reality. Therefore, INAB proceeded to perform an analysis to evaluate the quality of the carbon layers map, which can be found in the folder in this link: https://drive.google.com/drive/folders/1Nc95OnOfDjvNTQDO4ALA2I2lDZ9GJs95?usp=drive_link.

<table>
<tr>
<td>Uncertainty associated with this parameter:</td>
<td>
Table 10. Uncertainty of the carbon strata after applying the Monte Carlo method.
<table>
<tr><th>Strata</th><th>Median</th><th>Uncertainty (%)</th></tr>
<tr><td>I</td><td>145.34</td><td>22.44</td></tr>
<tr><td>II</td><td>101.57</td><td>97.88</td></tr>
<tr><td>III</td><td>109.93</td><td>77.29</td></tr>
<tr><td>IV</td><td>153.70</td><td>60.80</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>
The values found in table 10 are the result of the modeling for the carbon strata for the calculation of the uncertainty of the emission reduction.
</td>
</tr>
<tr>
<td>Any comment:</td>
<td>
To access the documents and calculations related to this activity, consult the following link:

Methodological report:
https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

Database to build the carbon strata of Guatemala:
https://docs.google.com/spreadsheets/d/1K7NZf9F5-ez1iYOvNYZmDcmrnmwYEa8o/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

Shapefile:
https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link
</td>
</tr>
</table>

Parameter:	Non forest carbon content Cnofor
Description:	Non-forest carbon content after conversion of forest land to non-forest land Used in equations:8 and 18
Data unit:	Tons of carbon/ha
Source of data or description of the method for developing the data, including the spatial level of the data (local,	In order to have an estimation of the emissions that is closer to reality and to assign a biomass existence value after deforestation, depending on the type of activity that is carried out, in addition to the data obtained for the country for agroforestry systems, the general default values were used for land converted to cropland during the year following conversion, from the 2006 IPCC Guidelines for Wet Tropical Annual and Perennial Crops and their associated error range found in IPCC Table 5.9 (2006). The values for these other non-forest use categories were used as described below (See Table 11): Table 11. Carbon in biomass after conversion due to deforestation.

regional, national or international) :

Other land uses	Ton Carbon/ha	Range of error and/or	Source
Croplands (all classes not specified) and grasslands	4.7	±75%	IPCC 2019 (Volume 4,Table 5.9, chapter 5 Croplands, annual croplands)
Croplands-Coffee (intensive)	2.65	±75%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in
Grasslands	6.73	±75%	IPCC 2006 (Table 6.4, chapter 6 Grasslands)
Croplands-African Palm	2.4	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Croplands-Rubber	3	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Agroforestry systems (shaded coffee)	20.1	1.34%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in Guatemala. PROMECAFE
Settlements	0.00	N/A	IPCC 2006
Wetlands	0.00	N/A	IPCC 2006
Other lands	0.00	N/A	IPCC 2006

Note: Since there are national values, it is suggested to leave this table to have all the non-forest carbon content values so that it is easier to replicate the Reference Levels and the Monitoring Period results in the process of rebuilding the estimation of reductions.

Value applied:

Other land uses	Ton Carbon/ha	Range of error and/or	Source

Croplands (all classes not specified) and grasslands	4.7	±75%	IPCC 2019 (Table 5.9, chapter 5 Croplands, annual croplands)
Croplands-Coffee (intensive)	2.65	±75%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in Guatemala. PROMECAFE
Grasslands	6.73	±75%	IPCC 2006 (Table 6.4, chapter 6 Grasslands)
Croplands-African Palm	2.4	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Croplands-Rubber	3	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Agroforestry systems (shaded coffee)	20.1	1.34%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in Guatemala. PROMECAFE
Settlements	0.00	N/A	IPCC 2006
Wetlands	0.00	N/A	IPCC 2006
Other lands	0.00	N/A	IPCC 2006

Note: Since there are national values, it is suggested to leave this table to have all the non-forest carbon content values so that it is easier to replicate the Reference Levels and the Monitoring Period results in the process of rebuilding the estimation of reductions.

QA/QC procedures applied	Does not apply because they are default values taken from the IPCC Guidelines.

Uncertainty associated with this parameter:

Table 12. Uncertainty of carbon content in non-forest land

Classification	Agriculture	Coffee	Palm	Rubber	Agroforestry	Grasslands
Mean	4.7	2.6	2.4	3.0	20.3	6.
Average	4.7	2.7	2.4	3.0	20.2	6.

Deviation	3.1	0.3	0.2	0.0	361.6	55.8
CI – lower limit	1.22	1.64	1.44	2.63	-16.72	-7.78
CI – upper limit	8.15	3.70	3.35	3.38	57.12	21.51
%	73.43	38.93	39.83	12.58	181.82	218.33

Any comment:	To access the documents and calculations related to this activity, consult the following link: Chapter Croplands for Croplands: https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch05_Cropland.pdf Chapter Croplands for African Palm and Rubber: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf Chapter Grasslands https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf Data for intensive coffee and Agroforestry systems (shaded coffee): https://drive.google.com/file/d/1kXI5Pxr_iUJOffJJTfVBTjF2iWihs3tq/view?usp=drive_link https://docs.google.com/presentation/d/1JjSan9z5CYySzZuhCwRWxW9c1tR2nyww/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

Parameter:	Emissions from degradation (Cfor-Cdeg)
Description:	Corresponds to the degradation that occurs between 30% to 70% of the forest carbon content. Used in equations: 9,19
Data unit:	Tons of carbon/ha
Source of data or description of the method for developing the data, including the spatial level of the data (local,	The degradation that occurs in areas that remain as forests was also included in the FREL. This phenomenon occurs due to a partial removal of trees that results in a decrease in forest cover in the monitoring period. This process implies loss of tree elements in aerial and underground carbon reservoirs, through the selective and intensive extraction of forest resources (trees for firewood, local use or commercial transformation) or the mortality of trees due to the effect of a forest fire. Fire degradation processes have been estimated to contribute up to 9% of national emissions (GIMBUT 2018b).

regional, national or international):

Degradation processes have also been identified with greater pressure from the unsustainable extraction of firewood for residential, commercial and industrial use, since it is estimated that 70% of households in Guatemala use it to cover their needs. Additionally, there are illegal extraction activities linked to the weakness of governance and it is estimated that 95% of the flow of forest products are of illicit origin with uncontrolled and selective extraction (GCI, 2018b).

Forest carbon content after the forest degradation process
To establish the content of forest degradation, it was assumed that this occurs when a Collect Earth plot loses between 30% to 70% of the elements that are categorized as trees and 50% of the initial forest content is lost, within the study period without reaching the deforestation process.

To establish the thresholds for forest degradation and degradation recovery, it was agreed with GIMBUT and the World Bank specialists to assume that the degradation and recovery process occurred between 30% and 70%, assuming that 50% is lost.

Value applied:

Above-ground carbon

Table 13. Criteria used to classify degraded plots.

Forest carbon strata	(tC/ha)
Forests I (>70%) to degraded (70-30%)	61
Forests II (>70%) to degraded (70-30%)	51
Forests III (>70%) to degraded (70-30%)	49
Forests IV (>70%) to degraded (70-30%)	63

For the criteria of using degradation thresholds, it was assumed that the plot in a degradation process loses 50% of the original forest carbon content. This assumption was validated with technicians from government institutions.

QA/QC procedures applied

Does not apply because they are default values, taken from the forest carbon content and emission factors used for deforestation.

The assumption was made that since 50% of the forest carbon content that is lost is used, the information used as a basis is the carbon strata map, so no new information was generated.

Uncertainty associated with this parameter:

Table 14. Forest degradation uncertainties.

Classification	Stratum 1	Stratum II	Stratum III	Stratum IV
Median	51	43	52	80
Average	53	62	82	124
Deviation	563	6,310	12,418	19,260
CI – lower limit	54	86	78	84
CI – upper limit	62	314	402	366
%	58	200	240	225

	These are the values corresponding to the forest carbon content that arise from the Montercarlo Model.
Any comment:	To access the documents and calculations related to this activity, consult the following link: Methodological report: https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link Database to build the carbon strata of Guatemala: https://docs.google.com/spreadsheets/d/1K7NZf9F5-ez1iYOvNYZmDcmrnmwYEa8o/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true Shapefile: https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link

Parameter:	Removals from forest degradation recovery (Cdeg-Cfor)
Description:	Corresponds to the forest carbon content that is recovered from degradation. This recovery occurs when 30% to 70% of the plot recovers the conditions. Used in equations: 10 and 20.
Data unit:	Ton of carbon/ha
Source of data or description of the method for developing the data, including the spatial level of the data (local, regional, national or international):	The recovery of degraded areas occurs in areas that remain as forests; it was also included in the FREL. This phenomenon occurs due to a partial recovery of trees that results in an increase in forest cover in the monitoring period. This process involves the recovery of tree elements in aerial and underground carbon reservoirs, through recovery, through selective and intensive anthropogenic activities of forest resources (restoration of forest areas). To establish the forest carbon content that is recovered from the forest degradation process, the plots that recovered 30% to 70% of the elements that were categorized as trees were used, and recover 50% of the forest carbon content. This occurs within the study period. To establish the thresholds for forest degradation and degradation recovery, it was agreed with GIMBUT and the World Bank specialists to assume that the degradation and recovery process occurred between 30% and 70%, assuming that 50% is lost. For the criteria of using recovered from the forest degradation thresholds, it was assumed that the plot in a degradation process loses 50% of the original forest carbon content. This assumption was validated with technicians from government institutions.

<table>
<tr>
<td>Value applied:</td>
<td>
<p>Above-ground carbon</p>
<p>Table 15. Criteria used to classify degraded plots.</p>
<table>
<tr><th>Classification</th><th>(tC/ha)</th></tr>
<tr><td>Forest I restored</td><td>61</td></tr>
<tr><td>Forest II restored</td><td>51</td></tr>
<tr><td>Forest III restored</td><td>49</td></tr>
<tr><td>Forest IV restored</td><td>63</td></tr>
<tr><td></td><td></td></tr>
</table>
<p>For the criteria for the use of degradation thresholds, it was assumed that the plot in a degradation recovery process recovers 50% of the original forest carbon content. This hypothesis was validated with technicians from governmental institutions.</p>
</td>
</tr>
<tr>
<td>QA/QC procedures applied</td>
<td>
<p>Not applicable at the moment, due to the approach used to calculate the data.</p>
<p>The assumption was made that since 50% of the forest carbon content that is lost is used, the information used as a basis is the carbon strata map, so no new information was generated.</p>
</td>
</tr>
<tr>
<td>Uncertainty associated with this parameter:</td>
<td>
<p>Table 16. Uncertainty of carbon contents in restored lands.</p>
<table>
<tr><th>Classification</th><th>Stratum 1</th><th>Stratum II</th><th>Stratum III</th><th>Stratum IV</th></tr>
<tr><td>Median</td><td>51</td><td>43</td><td>52</td><td>80</td></tr>
<tr><td>Average</td><td>53</td><td>62</td><td>82</td><td>124</td></tr>
<tr><td>Deviation</td><td>563</td><td>6,310</td><td>12,418</td><td>19,260</td></tr>
<tr><td>CI – lower limit</td><td>54</td><td>86</td><td>78</td><td>84</td></tr>
<tr><td>CI – upper limit</td><td>62</td><td>314</td><td>402</td><td>366</td></tr>
<tr><td>%</td><td>58</td><td>200</td><td>240</td><td>225</td></tr>
</table>
<p>These are the values corresponding to the forest carbon content that arise from the Montercarlo Model.</p>
</td>
</tr>
<tr>
<td>Any comment:</td>
<td>
<p>To access the documents and calculations related to this activity, consult the following link:</p>
<p>Methodological report:
https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link</p>
<p>Database to build the carbon strata of Guatemala:
https://docs.google.com/spreadsheets/d/1K7NZf9F5-ez1iYOvNYZmDcmrnmwYEa8o/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true</p>
</td>
</tr>
</table>

	Shapefile: https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link

<table>
<tr><td>Parameter:</td><td>Removals due to increased carbon through forest plantations (AAI)</td></tr>
<tr><td>Description:</td><td>Carbon content that is recovered through the implementation of coniferous and broadleaf plantations.</td></tr>
<tr><td>Data unit:</td><td>Tons of carbon per hectare</td></tr>
<tr><td>Source of data or description of the method for developing the data, including the spatial level of the data (local, regional, national or international):</td><td>
<p>To estimate this data, data from growth curves taken from 28 species of trees in forest plantations in Guatemala were used (INAB 2014). These results come from the assessment of sampling units called “Permanent Forest Measurement Plots (<i>PPMF, for its acronym in Spanish</i>),” which are distributed in 90 municipalities within the 22 departments of Guatemala, and their location is due to the behavior of the geographical distribution of the forest plantations established mainly with the PINFOR Forestry Incentive Program of the National Forest Institute (INAB) since 1998.</p>
<p>The Average Annual Growth Increments (AAGIs) were obtained by dividing the forest species by type of forest (broadleaf and coniferous), identifying which type of forest each forest species belongs to. Robust estimates of AAGIs for broadleaf and coniferous forests were generated from the Permanent Forest Measurement Plots (PPMF) database. The best fitted functions to probability density data (PDD) are normal for broadleaf forests and gamma for coniferous forests. Monte Carlo simulations were performed on these distributions to make more precise estimates and the final values of the AAGIs were calculated. Table 17 show the AAGIs for each plantation type in Guatemala.</p>
<p>Table 17. AAGI for each type of forest plantation.</p>
<table>
<tr><th>Capture factor</th><th>Median
(m^3 ha^{-1} $year^{-1}$)</th></tr>
<tr><td>AAGI in broadleaf forest</td><td>3.43</td></tr>
<tr><td>AAGI in coniferous forest</td><td>7.88</td></tr>
</table>
<p>The document called “Wood Densities of Tropical Tree Species” was used for the selection of wood densities. It contains a scientific study of tree densities in tropical forests in America. Also, as support and by way of comparison, the document “Conifers of Guatemala” was used, which contains densities of tree species belonging to the coniferous forest group (DATAFORG 2000, Reyes et al. 1992).</p>
<p>With the ordered basic density data, an average wood density was obtained for the broadleaf and coniferous forest. To obtain the average wood density for each type of forest, the species belonging to each tree community were identified and the arithmetic mean was calculated (See Table 18).</p>
</td></tr>
</table>

Table 18. Wood density according to the different types of plantations.

Type of forest	Density g/cm^3
Broadleaf Forests	0.62
Coniferous Forests	0.61

Biomass Expansion Factors (BEFs) are added to these values, which correspond to the ratio between aerial biomass and below-ground biomass (AB:BB) and the carbon fraction (CF), with IPCC default values, as shown below (See Table 19).

Table 19. Expansion factors, below-ground aerial biomass ratio and carbon fraction for forest plantations.

	BEF	AB:BB	CF
Broadleaf Forest	1.50	0.2	0.47
Coniferous Forest	1.20	0.2	0.47

Finally, the carbon per hectare per year data is converted to a COe_{q2} removal or absorption factor by multiplying it by the IPCC default factor of 44/12. Once all the calculations have been made, the values for plantations in broadleaf forests and plantations in coniferous forests are obtained (See **Error! Reference source not found.**).

Value applied:

Above-ground carbon.

Table 20. Values for plantations in broadleaf forests and plantations in coniferous forests

Classification	**AAI (tC/ha)**	**RF (t CO_{2eq}/ha)**
Broadleaf Forest	1.80	6.60
Coniferous Forest	3.25	11.93

QA/QC procedures applied

Not applicable at the moment, due to the approach used to calculate the data.

The following criteria were used to filter the information on forest plantations:

- Records of plantation initiation between the years 2001 to 2010.
- Agroforestry systems and reforestation modality (on the recommendation of Winrock International's advisors, the quantification of existing areas of
- Agroforestry Systems within the PINPEP forestry incentive, as these are incentivized areas that are sequestering carbon).
- The records should contain location polygon not points.

<table>
<tr><td></td><td>
Plantation area in hectares for each record.
<p>Based on the criteria described above, the data was cleaned and selected using software for geographic data management. For more information, in the any comments section you can find the protocol to calculate the IMA.</p>
</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>
<p>Table 21. Uncertainty of carbon contents in lands that are recovered through forest plantations.</p>
<table>
<tr><th>Classification</th><th>Broadleaf Forest</th><th>Coniferous Forest</th></tr>
<tr><td>Median</td><td>37,823</td><td>85,258</td></tr>
<tr><td>Average</td><td>82,184</td><td>101,185</td></tr>
<tr><td>Deviation</td><td>22,808,404,571</td><td>4,778,004,942</td></tr>
<tr><td>CI – lower limit</td><td>3,088</td><td>14,698</td></tr>
<tr><td>CI – upper limit</td><td>414,596</td><td>271,351</td></tr>
<tr><td>%</td><td>536</td><td>148</td></tr>
</table>
</td></tr>
<tr><td>Any comment:</td><td>
<p>To access the documents and calculations related to this activity, consult the following link:</p>
<p>Database:</p>
<p>https://drive.google.com/drive/folders/1QFuxCTGlG_qJXF4JLCOvxUWVugyRr8HX?usp=drive_link</p>
<p>Document:</p>
<p>https://drive.google.com/file/d/1tS8nzi-YlzMB-JWCCuH94vk2p_WwPEGc/view?usp=drive_link</p>
</td></tr>
</table>

3.2 Monitored Data and Parameters

Parameter:	Deforestation
Description:	Forest land converted to non-forest uses The following equations were used to calculate this parameter: Activity data: Equation 13 Additionally, to convert the data to emissions we used equation 1*8*.
Data unit:	Hectares
Value monitored	For deforestation, the land representation categories being used are those according to the IPCC.

during this Monitoring/Reporting Period:

Table *22*. Deforestation within the monitoring period

Classification	(Ha)
Forest I to cropland	958.89
Forest II to cropland	3,835.58
Forest III to cropland	958.89
Forest IV to cropland	0
Forest I to cropland-coffee	0
Forest II to cropland-coffee	0
Forest III to cropland-coffee	0
Forest IV to cropland-coffee	0
Forest I to cropland-African palm	0
Forest II to cropland-African palm	958.89
Forest III to cropland-African palm	0
Forest IV to cropland-African palm	0
Forest I to cropland-rubber	0
Forest II to cropland-rubber	0
Forest III to cropland-rubber	0
Forest IV to cropland-rubber	0
Forest I to agroforestry systems	958.89
Forest II to agroforestry systems	958.89
Forest III to agroforestry systems	958.89
Forest IV to agroforestry systems	0
Forest I to grasslands	14,383.42
Forest II to grasslands	8,630.05
Forest III to grasslands	6,712.26
Forest IV to grasslands	1,917.79
Forest I to settlements	0
Forest II to settlements	958.89
Forest III to settlements	0
Forest IV to settlements	0
Forest I to other lands	0
Forest II to other lands	1,917.79
Forest III to other lands	0
Forest IV to other lands	958.89
Forest I to wetlands and bodies of water	0
Forest II to wetlands and bodies of water	0
Forest III to wetlands and bodies of water	0
Forest IV to wetlands and bodies of water	0

Source of data and description of

To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed.

<table>
<tr><td>measurement/ calculation methods and procedures applied:</td><td>
<p>To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link</p>
<p>The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez.</p>
<p>For the identification of deforestation, plots were identified in which, during the 2018-2020 period, they lost their entire forest cover or suffered a degradation process greater than 70% loss of the elements corresponding to trees.</p>
<p>After interpreting the 11,369 and labeling the change, a filter was made to identify those points that were deforestation. 47 points were identified within the program area, to then use the equation found in section 3.1.1 to obtain the data on hectares of deforestation. For monitoring, a total of 47 deforestation points were identified, which is equivalent to a total of 42,068.05 ha.</p>
<p>After the identification of the deforested plots, the forest stratum was identified for each of the plots and the carbon content was assigned. Then, the non-forest cover to which the plot passed was identified and the carbon content for this use was assigned.</p>
<p>The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".</p>
<p>https://docs.google.com/spreadsheets/d/1IxckyzBxOS9hz7iGPR9IH58rLAf796Ju/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true</p>
<p>In the tab Program Report 18-20 and column D, in the section corresponding to Deforestation is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the year's corresponding to the monitoring.</p>
</td></tr>
<tr><td>QA/QC procedures applied:</td><td>
<p>A review of the non-logical changes was made and the information corresponding to the land cover that did not match was updated.</p>
<p>For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</p>
</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>
<p>Table 23. Uncertainties for deforestation in the monitoring period</p>
<table>
<tr><th>Classification</th><th>Deforestation</th></tr>
<tr><td>Median</td><td>44,951.1</td></tr>
<tr><td>Average</td><td>45,032.8</td></tr>
<tr><td>Deviation</td><td>42,905,355.4</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td><table><tr><td>CI – lower limit</td><td>32,024.6</td></tr><tr><td>CI – upper limit</td><td>58,084.9</td></tr><tr><td>%</td><td>29.0</td></tr></table></td></tr>
<tr><td>Any comment:</td><td>To access the documents and calculations related to this activity, consult the following link:
Activity data
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link</td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>Degradation</td></tr>
<tr><td>Description:</td><td>Degraded forest land
The following equations were used to calculate this parameter:
Activity data: Equation 14
Additionally, to convert the data to emissions we used equation 1<i>9</i>.</td></tr>
<tr><td>Data unit:</td><td>Hectares</td></tr>
<tr><td>Value monitored during this Monitoring/Reporting Period:</td><td>Table 24. Hectares that have been degraded within the 2016-2020 period
<table><tr><th>Classification</th><th>(Ha)</th></tr><tr><td>Forest I (>70%) to degraded (70-30%)</td><td>14,383</td></tr><tr><td>Forest II (>70%) to degraded (70-30%)</td><td>32,602</td></tr><tr><td>Forest III (>70%) to degraded (70-30%)</td><td>23,013</td></tr><tr><td>Forest IV (>70%) to degraded (70-30%)</td><td>14,383</td></tr></table></td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez

For degradation, the three interpreters identified a total of 88 points within the four forest strata that were identified for Guatemala. Of these 88 points, 15 correspond to Stratum 1, 34 to Stratum II, 24 to Stratum III and finally 15 to Stratum IV.

This analysis is performed on forest land that is maintained as such. To identify plots with forest degradation, the following equation is used:</td></tr>
</table>

<table>
<tr>
<td></td>
<td>

$$Degradation = 100 * \frac{Year\ 2020 * 100}{Year\ 2016}$$

The analysis is done at the grid points, which remain as forest land or forest. Subsequently, the analysis of the loss of the elements that were categorized as trees is made. If the point loses between 30% and 70% of the trees, it is categorized as forest degradation.

The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".

In the Program Report 18-20 tab and column D of the Degradation section (Rows 45-48) is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the years corresponding to the monitoring.

</td>
</tr>
<tr>
<td>QA/QC procedures applied:</td>
<td>For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</td>
</tr>
<tr>
<td>Uncertainty for this parameter:</td>
<td>

Table 25. Uncertainties of degradation in the monitoring period

<table>
<tr><th>Classification</th><th>Degradation</th></tr>
<tr><td>Median</td><td>84,301.2</td></tr>
<tr><td>Average</td><td>84,214.0</td></tr>
<tr><td>Deviation</td><td>80,521,353.3</td></tr>
<tr><td>CI – lower limit</td><td>66,956.1</td></tr>
<tr><td>CI – upper limit</td><td>102,067.1</td></tr>
<tr><td>%</td><td>20.8</td></tr>
</table>

</td>
</tr>
<tr>
<td>Any comment:</td>
<td>

To access the documents and calculations related to this activity, consult the following link:

Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

</td>
</tr>
</table>

Parameter:	Forest Degradation Recovery

<table>
<tr><td>Description:</td><td>Land recovered from forest degradation
The following equations were used to calculate this parameter:
Activity data: Equation 15
Additionally, to convert the data to emissions we used equation 20.</td></tr>
<tr><td>Data unit:</td><td>Hectares</td></tr>
<tr><td>Value monitored during this Monitoring/Reporting Period:</td><td>Table 26. Hectares of forest increments through forest restoration.
<table>
<tr><th>Classification</th><th>(Ha)</th></tr>
<tr><td>Forest I restored</td><td>52,739</td></tr>
<tr><td>Forest II restored</td><td>77,670</td></tr>
<tr><td>Forest III restored</td><td>54,657</td></tr>
<tr><td>Forest IV restored</td><td>19,178</td></tr>
</table></td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link
The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez
To calculate the recovery from degradation, a total of 213 points were identified in the four forest strata of the program. Of these 213 points, 55 correspond to Stratum I, 81 to Stratum II, 57 to Stratum III and 20 to Stratum IV. It is important that this analysis is done within the points that maintain their forest cover, and that recover 30% to 70% of the elements corresponding to trees. To carry out this analysis, the following equation is used:
$$Degradation\ recovery = 100 * (\frac{Year\ 2016 * 100}{Year\ 2020})$$
After knowing the total number of points that were identified as recovery from degradation, the equation found in section 3.1.3 was used to obtain the data in hectares, and then divided by two years to obtain the data in hectares per year.
The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".
In the Program Report 18-20 tab and column D of the Degradation section (Rows 49-52) is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the years corresponding to the monitoring.</td></tr>
</table>

QA/QC procedures applied:

For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.

Uncertainty for this parameter:

Table 27. Restoration uncertainties of degraded areas

Classification	Restoration
Median	204,288.9
Average	204,262.6
Deviation	190,715,024.6
CI – lower limit	176,772.0
CI – upper limit	232,084.8
%	13.5

Any comment:

To access the documents and calculations related to this activity, consult the following link:

Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

Parameter:

Increased Carbon Through Forest Plantations

Description:

Increased Carbon Through Forest Plantations

The following equations were used to calculate this parameter:

Activity data: Equation 15

Additionally, to convert the data to emissions we used equation 20.

Data unit:

Hectares

Value monitored during this Monitoring/Reporting Period:

Table 28. Hectares per year of carbon increases through forest plantations.

Classification	(Ha)
Profit Coniferous Plantations	959
Profit Broadleaf Plantations	-

<table>
<tr><td></td><td></td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>
<p>To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link</p>
<p>The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez.</p>
<p>Regarding the information on forest plantations, only one plot corresponding to coniferous plantations was identified. To obtain the data per hectare, the equation found in section 3.1.4 was used.</p>
<p>The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".</p>
<p>https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link</p>
<p>In the Program Report 18-20 tab and column D of the Degradation section (Row 53) is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the years corresponding to the monitoring.</p>
</td></tr>
<tr><td>QA/QC procedures applied:</td><td>For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>
<p>Table 29. Forest plantation uncertainties</p>
<table>
<tr><th>Classification</th><th>Plantations</th></tr>
<tr><td>Median</td><td>973.8</td></tr>
<tr><td>Average</td><td>977.6</td></tr>
<tr><td>Deviation</td><td>907,138.1</td></tr>
<tr><td>CI – lower limit</td><td>- 916.5</td></tr>
<tr><td>CI – upper limit</td><td>2,853.4</td></tr>
<tr><td>%</td><td>193.6</td></tr>
</table>
</td></tr>
<tr><td>Any comment:</td><td>
<p>To access the documents and calculations related to this activity, consult the following link:</p>
<p>Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link</p>
</td></tr>
</table>

	Calculation of hectares and emissions/absorptions https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

4 QUANTIFICATION OF EMISSION REDUCTIONS

4.1 ER Program Reference level for the Monitoring / Reporting Period covered in this report

Monitoring Year/Reporting Period t	Annual average of historical emissions derived from deforestation during the Reference Period (tCO_{2eq}/year)	If applicable, annual average of historic emissions from forest degradation during the Reference Period (tCO_{2eq}/year)	If applicable, annual average of historical removals by sinks during the Reference Period (tCO_{2eq}/year)	Adjustment, if applicable (tCO_{2eq}/year)	Reference level (tCO_{2eq}/year)
2020	10,412,105.49	3,756,434.67	-2,354,302.98		11,814,237.18
Total	10,412,105.49	3,756,434.67	-2,354,302.98		11,814,237.18

4.2 Estimation of emissions by sources and removals by sinks included in the ER Program's scope

Monitoring Year/Reporting Period	Emissions from deforestation (tCO_{2eq}/year)	If applicable, emissions from forest degradation (tCO_{2eq}/year) *	If applicable, removals through sinks (tCO_{2eq}/year)	Net emissions and removals (tCO_{2eq}/year)
2020	8,513,391.94	4,174,400.83	-10,110,766	2,577,026.82
Total	8,513,391.94	4,174,400.83	-10,110,766	2,577,026.82

4.3 Calculation of emission reductions

Total reference level of emissions during the reporting period (tCO_{2eq})	11,814,237.18
Net emissions and removals under the ER Program during the reporting period (tCO_{2eq})	2,577,026.82
Reduction of emissions during the reporting period (tCO_{2eq})	9,237,210.35

To access the calculations of the reference level, as well as the monitoring period, you can access the following link:

Document “Estimacion_ Emisiones_Guatemala_NRF_MR_15Jjunio20_subir”:

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

1. To consult the summary data, consult the “Summary Data” tab.
2. Emissions/Removals corresponding to the reference level, see the “NR Program” tab.
3. Emissions/absorptions corresponding to the monitoring period, consult the "2018-2020 Report Program" tab.

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

5.1 Identification, assessment and addressing sources of uncertainty

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Activity Data						
Measurement		X	In the case of Guatemala, according to the sampling carried out for the generation of activity data, there may be sources of error associated with the quality and resolution of satellite images, the visual interpretation of samples, and sampling design. The error associated with the quality and resolution of the images could be considered low, since medium and high-resolution images have been used and the size of the analyzed plot (1ha) allows a correct visual interpretation of the images. In addition, the use of the Collect Earth tool allows to visualize the best images available on the dates of interest, ensuring to have images without clouds and with the requirements for their proper interpretation and reducing as much as possible the uncertainty that originates from this source. Another source of uncertainty comes from the main process for the estimation of the DA which is the visual interpretation of each of the points of the grid, for this part there has been a series of processes to minimize errors, with the choice of professional interpreters, who have gone through a training process on the use of the tools, an interpretation protocol has been developed which is the basis for the definition of classes.	High	Yes	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			In addition, some scripts have been programmed to facilitate interpretation and avoid making mistakes during this process; a reliability value is even assigned to each of the data that is collected at each point in the mesh. Finally, a review of 5% of the samples is made by 3 interpreters and a comparative matrix of each evaluated point is made and a percentage of error is obtained in the interpretation of each of the original interpreters. For the measurement of the four REDD+ activities in Guatemala: A mesh composed of 11,369 samples was used, which was used both at the reference level and in the first monitoring. With the sample mesh, the objective was to collect the land cover using the six IPCC classes and which were entered into a Collec Earth desktop form to display and interpret the high-resolution images for the year of study. Each plot on the Collect Earth form was made up of 25 elements for which coverage was assigned based on these elements, which could be trees, grasslands, agricultural land, bare soil, bodies of water and wetlands, as well as other land. In this way, each one of the interpreters was assigned a total of 3,700 plots (average) for each one to carry out the visual interpretation using the high-resolution images of Google Earth that were synchronized with Collect Earth. The imagery source was primarily high-resolution Google Earth imagery, followed by Planet, Sentinel, and Landsat imagery only when no imagery was available in Google Earth, or there were clouds or shadows in the Google Earth image.			

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			After the interpretation of the 11,369, the classes of change or permanence were identified with labels to identify deforestation, degradation, and carbon increases through recovery from degradation and forest plantations. In this exercise, a review was made to assess the consistency of the coverage of the plot and whether it was coherent with the other dates. This process was carried out in an Excel sheet. After processing the labels, the total points for each of the four activities of the program were counted and then in another Excel tool to calculate hectares, total carbon and finally to be able to calculate the total number of CO2 emissions and absorptions. To reduce the error derived from visual interpretation, the Collect Earth methodological protocol was used to homogenize criteria among the interpreters, a forum was created in which the interpreters, when they had a sample with great difficulty, helped each other and how exercises were also done. to assess the degree of agreement between them as part of quality control. For the interpretation of the plots, 638 plots were interpreted and the information was cross-checked to obtain the percentage of coincidence between the three interpreters. Due to the restrictions derived from the COVID-19 pandemic, the interpreters worked remotely, sending their results every 15 days to be reviewed. It is important to mention that among the interpreters there was communication with them to resolve doubts if the plot was too difficult to interpret.			

Sources of uncertainty	**Systematic**	**Random**	**Analysis of contribution to overall uncertainty**	**Contribution to overall uncertainty (High / Low)**	**Addressed through QA/QC?**	**Residual uncertainty estimated?**
			The temporal analysis was also done to identify possible incongruent transitions since having four points in time allowed to find out those non-logical changes that the plot could obtain. All this process was carried out using the Excel tool to process the information. When these non-logical changes were identified, the plot was reviewed again and the information was edited to ensure that the plot information was correct. Of the total of 638 samples for transitions and permanence that were identified for both the first monitoring and the reference level that was reviewed. For deforestation and degradation, 48 and 42 samples were established, while for carbon increments through degradation recovery and plantations, the samples were 56 and 18 respectively. These subsequent samples were chosen randomly and with a confidence interval of 95% and an error of 5%. Finally, it is important to mention that it can be considered that the interpreters do not have the same experience to interpret satellite images, so it is possible that the interpretation error is high.			
Representative ness			To detect areas of change due to emissions and removals from deforestation, degradation, and increases in carbon stocks, Guatemala used a multipurpose grid to collect information. This grid was prepared in the context of the second forest inventory of Guatemala, which seeks to be able to represent the soil cover with a sampling precision of 10% with a confidence interval of 95%, which is sufficient with 672 samples.	Low	Yes	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			With this information, Guatemala decided to use a 3.1x3.1 grid system using a non-aligned systematic sampling design, making the sample proportional to the country's area. Within each grid, a randomly located point was located, thus allowing the evaluation of the change in use of the land cover. The grid design generated a total of 11,369 points located randomly within each grid for the entire surface of the country. After locating the 11,369 samples, a Collect Earth form was generated to collect the information using high-resolution images found in the Google Earth image catalog. In the event that a High Resolution image is not available, images from the Landsat, Sentinel or Planet family are used depending on their availability. This Collect Earth form asked about the six IPCC classes as well as other land cover based on the land cover mapping of Guatemala. If, in case, a change was detected, the form indicated what kind of coverage it went to, as well as the year and the sensor with which the information was captured. Within the actions to minimize the error due to the collection of information, Guatemala generated an interpretation protocol so that each specialist or interpreter could address it in case they had doubts when choosing the land cover. Monthly meetings were also held to resolve doubts that had a high degree of interpretation, but since most of the images are of high resolution, it can be considered that the protection against uncertainty due to the collection of information is low.			

Sources of uncertainty	**Systematic**	**Random**	**Analysis of contribution to overall uncertainty**	**Contribution to overall uncertainty (High / Low)**	**Addressed through QA/QC?**	**Residual uncertainty estimated?**
Sampling			Regarding sampling error, this is the type of error that is quantified for its propagation in uncertainty, the sampling design is systematic with a mesh of 3.1 km x 3.1 km with a site located within each of the quadrants of the mesh. With the density of the sample you have, it is enough to capture the dynamics of the forests with an acceptable error. However, if you wanted to make an estimate of a smaller area, or for a specific type of change, this would require a densification of the mesh in those areas of interest. The value used for uncertainty propagation is the sampling error that comes from the activity data for each of the transitions that are identified.	Low	Yes	Yes
Extrapolation			Not apply			
Approach 3			This source of uncertainty is not applicable. Activity data were estimated conducting tracking of lands or IPCC Approach 3 for reference and monitoring periods	High	Yes	No
Emission Factor						
DAP measurement		X	The measurement of the DAP was measured directly since information from different forest inventories that various projects in Guatemala have implemented over time was used. In Guatemala, a tree is defined as having a DAP greater than 10 centimeters at breast height. Being information coming from various sources of forest inventories, there is no estimate of random or systematic errors that can contribute to the total uncertainty, because what can be considered high contribution.	High	No	No
H measurment		X	The allometric equations used to generate the carbon strata map do not use height to estimate carbon content.	High	No	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Plot delination		X	The use of plots of different origins and sizes leads to considerable errors, in addition to the fact that each group of plots has different purposes and therefore different types of sampling, gives us an idea that EFs are one of the main sources of uncertainty in the estimation of emissions and removals. In this case, weightings were made according to the size of the different plots and the values were used to generate a map of carbon strata. In this process, modeling was done with the Monte Carlo and Bootstrap method to better represent the distribution functions of the sample used, which means that the errors of each FE reported on the map become considerably low (see the FE section and the Carbon Strata Map protocol). There was no control over the size and shape of the plot, nor in the process of plot establishment.	High	No	No
Biomass allometric model		X	For the calculation of biomass, three allometric equations were used for natural forests, both broadleaf and coniferous, the latter were standardized through studies carried out by the Universidad del Valle de Guatemala: UVG (2015) for coniferous, UVG (2015) for broadleaf ; and for the northern lowlands the equation of Williams Arreaga (2002), with these the aerial biomass was calculated for each tree (includes from the stem to the branches), using only the DAP (diameter at height of 1.3 m). In the case of the mangrove forest, three equations were applied according to the species found (permanent sampling plots from the southern coast of Guatemala administered by INAB were used).	High	No	No
Sampling			The sampling design for the calculation of forest carbon of the plots varies since there are data from plots with a size ranging from 0.02 to 1 hectare in size of the plot, this	High	No	Yes

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			because the collection of more than 3,000 plots distributed in most of Guatemala and covering more than 203 thousand trees that were inventoried. Derived from the fact that this information also comes from various information sources and it is not clear if there were quality control processes, this causes the contribution of sampling uncertainty to be high. For the propagation of the error, the probabilistic density function values were used for each of the carbon strata and for each of the different plot sizes with which the four strata of the carbon map were developed.			
Other parameters (e.g. Carbon Fraction, rootto-shoot ratios)			For the carbon fraction, the IPCC factor 0.47 was used, while to establish the belowground carbon fraction, the Mokany equation was used because it was established that this equation was the most appropriate in proportion to the area biomass. Using the forest carbon content per hectare, the Mokany equation was applied to obtain the proportion of subterranean carbon. This information is integrated in the carbon strata map so that the error cannot be propagated.	High	Yes	No
Representativeness			The map of carbon strata covers the entire territory since plots from different forest inventories in Guatemala were used to ensure that forest carbon is represented on the map. Also, as part of the review by the UNFCCC reference level, an analysis was made on the correspondence of the map information with INAB's physical plots (document included in annexed folder 01.Datos_Fuentes/01.	High	Yes	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			Carbono_forestal/Mapa Estratos de Carbono / 01_ControCalidad).			
Integration						
Model			There is an Excel file containing all the variables to estimate the uncertainty of the reductions. We will be working for the second monitoring in a manual to perform this calculation. All sources of error were quantified in the activity data and emission factors, which were propagated in the integration, so it is assumed that the uncertainty calculation will be low. In addition, a logic function was performed within the tool to estimate emissions/removals to verify that the total area of the points coincides with the total area of the program.	Low	No	No
Integration			Emission factors were calculated for each forest stratum according to the location of the dot mesh plots to ensure comparability between the transition classes of activity data and those of emission factors. This source of uncertainty is considered as one of the main sources of uncertainty.	High	Yes	No

5.2 Uncertainty of the estimate of Emission Reductions

Uncertainty in emission reduction estimates

Parameters and assumptions used in the Monte Carlo method

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
Reference Level (RL)					
Forest carbon content (tonC/ha)					
Forest carbon content -Strate I-	0.03	k = 1.553; beta = 106.475	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
	0.04	µ = 220.867; sigma = 30.44	Error due to different sizes of forest stands used to calculate carbon content.	Normal	Minimum value assumed to be 0

	0.05	gamma = 82.476;
		beta = 1.647;
		µ = 12.195
			Error due to different sizes of forest stands used to calculate carbon content.	Weibull (3)	Minimum value assumed to be 0

	0.1	gamma = 124.079; beta = 2.329	Error due to different sizes of forest stands used to calculate carbon content.	Weibull (2)	Minimum value assumed to be 0
	0.13	µ = 346.731; sigma = 30.352	Error due to different sizes of forest stands used to calculate carbon content.	Normal	Minimum value assumed to be 0
	0.25	µ = 116.878; s = 16.518	Error due to different sizes of forest stands used to calculate carbon content.	Logística	Minimum value assumed to be 0
	1	µ = 101.778; s = 12.542	Error due to different sizes of forest stands used to calculate carbon content.	Logística	Minimum value assumed to be 0

	2	alfa = 0.432;
		beta = 0.641;
		c = 7.854;
			Error due to different sizes of forest stands	Beta4	Minimum value assumed to be 0

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
		d = 75.214	used to calculate carbon content.		
Forest carbon content -Strate II-	0.03	μ = 4.329; sigma = 1.065	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	0.05	μ = 4.656; sigma = 1.04	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	0.1	Gamma = -0.071 beta = 53.543; μ = 73.854	Error due to different sizes of forest stands used to calculate carbon content.	GEV	Minimum value assumed to be 0
	0.25	μ = 4.566; sigma = 0.843	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	2	k = 0.42; beta = 86.609	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
Forest carbon content -Strate III-	0.03	μ = 4.787; sigma = 1.143	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0

	0.05	gamma = 85.775;
		beta = 1.08;
		μ = 17.098
			Error due to different sizes of forest stands used to calculate carbon content.	Weibull (3)	Minimum value assumed to be 0

	0.1	μ = 4.735; sigma = 0.846	Error due to different sizes of forest stands	Log-normal	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
			used to calculate carbon content.		
	0.13	Gamma = -0.05 beta = 28.323; µ = 75.046	Error due to different sizes of forest stands used to calculate carbon content.	GEV	Minimum value assumed to be 0
	0.25	Gamma = -0.164 beta = 29.65; µ = 108.335	Error due to different sizes of forest stands used to calculate carbon content.	GEV	Minimum value assumed to be 0
	2	µ = 53.841; sigma = 36.152	Error due to different sizes of forest stands used to calculate carbon content.	Normal	Minimum value assumed to be 0
Forest carbon content -Strate IV-	0.03	k = 1.368; beta = 215.458	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
	0.04	gamma = 204.913; beta = 20.465	Error due to different sizes of forest stands used to calculate carbon content.	Weibull (2)	Minimum value assumed to be 0
	0.05	µ = 4.169; sigma = 0.703	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	0.1	µ = 5.154; sigma = 1.051	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0

	0.12	alfa = 0.515;
		beta = 0.722;
		c = 109.721;
			Error due to different sizes of forest stands	Beta4	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
		d = 183.871	used to calculate carbon content.		

	0.13	alfa = 0.327;
		beta = 0.246;
		c = 69.965;
		d = 160.387
			Error due to different sizes of forest stands used to calculate carbon content.	Beta4	Minimum value assumed to be 0

	2	k = 1.518; beta = 33.312	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
Conifer plantation	N/A	k = 2.597; beta = 3.468	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
Broadleaf Plantation	N/A	μ = 1.247; sigma = 1.198	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
Non-forest carbon content (tonC/ha)					
Annual agricultural land	N/A	4.7	IPCC default value	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Agricultural-coffee land	N/A	2.65	IPCC default value	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Agricultural land-African palm	N/A	2.4	IPCC default value	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Agricultural land-rubber	N/A	3	IPCC default value	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Agroforestry systems	N/A	20.1	Error due to different sizes of forest stands used to calculate carbon content.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Grasslands	N/A	6.73	IPCC default value	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Deforestation and degradation					
Carbon I stratum to annual agricultural land	N/A	Area (ha): 7,671.16 SD (ha): 2,711.25	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum II to annual agricultural land	N/A	Area (ha): 19,177.89 SD (ha): 4,284.39	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum III to annual agricultural land	N/A	Area (ha): 9,588.95 SD (ha): 3,030.98	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum IV to annual agricultural land	N/A	Area (ha): 6,712.26 SD (ha): 2,536.27	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon I stratum to agricultural-coffee land	N/A	Area (ha): 2,876.68 SD (ha): 3,255	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Carbon II stratum to agricultural-coffee land	N/A	Area (ha): 2,876.68 SD (ha): 1,660.69	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum to agricultural-coffee land	N/A	Area (ha): 0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon IV stratum to agricultural-coffee land	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon I stratum to agricultural land-African palm	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon II stratum to agricultural land-African palm	N/A	Area (ha): 8,630.05 SD (ha): 2,875.58	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum to agricultural land-African palm	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon IV stratum to agricultural land-African palm	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon I stratum to agricultural land-rubber	N/A	Area (ha): 0 SD (ha): 0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Carbon II stratum to agricultural land-rubber	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum to agricultural land-rubber	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon IV stratum to agricultural land-rubber	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum I to agroforestry systems	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum II to agroforestry systems	N/A	Area (ha): 3,835.58 SD (ha): 1,917.51	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum III to agroforestry systems	N/A	Area (ha): 2,876.68 SD (ha): 1,660.69	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum IV to agroforestry systems	N/A	Area (ha): 3,835.58 SD (ha): 1,917.51	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon I stratum to grasslands	N/A	Area (ha): 79,588.26 SD (ha): 8,701.48	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
Carbon II stratum to grasslands	N/A	Area (ha): 71,917.11 SD (ha): 8,274.71	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum to grasslands	N/A	Area (ha): 31,643.53 SD (ha): 5,499.96	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon IV stratum to grasslands	N/A	Area (ha): 5,753.37 SD (ha): 2,348.24	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon I stratum to settlements	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon II stratum to settlements	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum to settlements	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon IV stratum to settlements	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum I to other lands	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Carbon Stratum II to other lands	N/A	Area (ha): 2,876.68 SD (ha): 1,660.69	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum III to other lands	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum IV to other lands	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon I stratum to wetlands and water bodies	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon II stratum to wetlands and water bodies	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum to wetlands and water bodies	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon IV stratum to wetlands and water bodies	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Degraded Carbon I Stratum (>30% and <70%)	N/A	Area (ha): 34,520.21 SD (ha): 5,743.69	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Degraded Carbon II Stratum (>30% and <70%)	N/A	Area (ha): 83,423.84 SD (ha): 8,906.96	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Degraded Carbon III Stratum (>30% and <70%)	N/A	Area (ha): 51,780.32 SD (ha): 7,028.45	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Degraded Carbon IV Stratum (>30% and <70%)	N/A	Area (ha): 22,054.58 SD (ha): 4,593.84	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Increases in carbon stocks					
Carbon I stratum recovered from degradation (>30% and <70%)	N/A	Area (ha): 31,644 SD (ha): 5,500	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon II stratum recovered from degradation (>30% and <70%)	N/A	Area (ha): 35,479 SD (ha): 5,823	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum recovered from degradation (>30% and <70%)	N/A	Area (ha): 31,644 SD (ha): 5,500	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum IV recovered from degradation (>30% and <70%)	N/A	Area (ha): 17,260 SD (ha): 4,065	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Non-forest land to coniferous plantations	N/A	Area (ha): 12,465.63 SD (ha): 3,455	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Non-forest land to broadleaf plantations	N/A	Area (ha): 15,342.32 SD (ha): 3,833	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Reporting period (GHG)					
Deforestation and degradation					
Carbon I stratum to annual agricultural land	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum II to annual agricultural land	N/A	Area (ha): 3,835.58 SD (ha): 1,917.51	Error due to the interpretation of the grid. Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum III to annual agricultural land	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon II stratum to agricultural land-African palm	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon I stratum to agricultural land-rubber	N/A	Area (ha): 0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum I to agroforestry systems	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Carbon Stratum II to agroforestry systems	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum III to agroforestry systems	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon I stratum to grasslands	N/A	Area (ha): 14,383.42 SD (ha): 3,711.29	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon II stratum to grasslands	N/A	Area (ha): 8,630.05 SD (ha): 2,875.58	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum to grasslands	N/A	Area (ha): 6,712.26 SD (ha): 2,536.27	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon IV stratum to grasslands	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon II stratum to settlements	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon Stratum II to other lands	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
Carbon Stratum IV to other lands	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Degraded Carbon I Stratum (>30% and <70%)	N/A	Area (ha): 14,383.42 SD (ha): 3,711.29	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Degraded Carbon II Stratum (>30% and <70%)	N/A	Area (ha): 32,602.42 SD (ha): 5,582.40	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Degraded Carbon III Stratum (>30% and <70%)	N/A	Area (ha): 23,013.47 SD (ha): 4,692.41	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Degraded Carbon IV Stratum (>30% and <70%)	N/A	Area (ha): 14,383.42 SD (ha): 3,711.29	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Increases in carbon stocks					
Carbon I stratum recovered from degradation (>30% and <70%)	N/A	Area (ha): 52,739.21 SD (ha): 7,092.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon II stratum recovered from degradation (>30% and <70%)	N/A	Area (ha): 77,670.47 SD (ha): 8,596.84	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Carbon III stratum recovered from	N/A	Area (ha): 54,657.00 SD (ha): 7,220.00	Error due to the interpretation of the grid.	It comes from the sampling error and is	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
degradation (>30% and <70%)				assumed to have a normal distribution.	
Carbon Stratum IV recovered from degradation (>30% and <70%)	N/A	Area (ha): 19,177.89 SD (ha): 4,284.39	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Non-forest land to coniferous plantations	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0
Non-forest land to broadleaf plantations	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	It comes from the sampling error and is assumed to have a normal distribution.	Minimum value assumed to be 0

Quantification of the uncertainty of the estimate of Emission Reductions

		Reporting Period	**Crediting Period**
		Total Emission Reductions*	**Total Emission Reductions***
A	**Median**	26,693,328.17	26,693,328.17
B	**Upper bound 90% CI** (Percentile 0.95)	43,586,638.14	43,586,638.14
C	**Lower bound 90% CI** (Percentile 0.05)	21,793,319.07	21,793,319.07
D	**Half Width Confidence Interval at 90% (B – C / 2)**	10,868,623	10,868,623
E	**Relative margin (D / A)**	83%%	83%%
F	**Uncertainty discount**	12%%	12%%

The MonterCarlo model can be accessed through the following link:
https://docs.google.com/spreadsheets/d/1Ir_rDYY0jLUhav8Tm6h3nctrREioR9qo/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

The model contains the following tabs:

- EstaAlmacenesPropError: parameters of forest and non-forest carbon contents.
- SimulForestSimul: simulations of forest carbon contents.
- Sions Report: Simulations of the emissions and removals of the monitoring period.
- RE: Simulation of emission reductions between the reference level and the monitoring period. mulNonForest: simulations of non-forest carbon contents.
- Deforest_Increment: simulations of emission and removal factors.
- DA NR: Simulations of reference level activity data.
- DA Report: Simulations of the monitoring period activity data.
- Emissions NR: Simulations of reference level emissions and removals.

For the model to run correctly in Excel, it is necessary to download and install the program NtRand, which allows to generate random numbers based on Mersenne Twister and provides several probability distributions and statistical utility functions and covers Monte Carlo VaR calculation.

NtRand can be downloaded using the following link: http://www.ntrand.com/

5.3 Sensitivity analysis and identification of areas of improvement of MRV system

>> The total uncertainty of emission reductions resulted in 72% in the four activities that have been implemented during the Emission Reduction Program stage. The uncertainties of each of the activities were distributed as follows:

- Deforestation: 77%
- Degradation: -132%
- Increments due to restoration: 117%
- Increments due to plantations: 80%

To determine the relative contribution of each parameter to the overall uncertainty, a sensitivity analysis was performed in which the REDD+ activities were selectively fixed and the Monte Carlo method was used to combine the uncertainties in the model simulations.
Table 31 shows the overall uncertainty of emission reductions shows that leaving the deforestation data fixed, the uncertainty of ER increases by 18%. Then the next parameter that increases the uncertainty is leaving the degradation data fixed, which increases the overall uncertainty by 6%. Forest degradation recovery and plantations do not have a significant impact on the overall uncertainty as there is a 1% reduction in the case for degradation recovery and 0% for plantations respectively.

Table 30. Senility analysis of emission reductions

Category	Percentage of uncertainty	Change with respect to general uncertainty
General uncertainty of emission reductions	72%	
Overall uncertainty of emission reductions -Keeping deforestation data fixed.	90%	-18% (increase)
Overall uncertainty of emission reductions -Keeping the degradation data fixed.	71%	1% (Decrease)
Overall uncertainty of emission reductions -Keeping the degradation recovery data fixed.	78%	-6% (Increase)
Overall uncertainty of emission reductions -Keeping the increase per plantation data fixed.	72%	0%

The negative data means an increase, since the general uncertainty data is being taken first to make the subtraction.

To view the sensitivity file (AnalsisiSensiblidad_v2), please click on the following link:
https://docs.google.com/spreadsheets/d/1IxFl5UbRkJFr1N20tpJY-xTROuN3hPbM/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

The Congress of the Republic of Guatemala, through the approval of Decree 20-2020, establishes that "The Ministry of Public Finance acts as the entity of the Program and that the Executing Unit is the National Institute of Forests", referring to the Emissions Reduction Program.

The Congress of the Republic of Guatemala, through the approval of Decree 20-2020 dated April 16, 2020, describe the beneficiaries and owners of the emission reductions titles as the land owners and land possessors, in accordance with article 22 of Decree 7-2013 of the Congress of the Republic, as well as the persons or entities that implement the measures described in the Program Document, in accordance with the Benefit Distribution Plan.

The Ministry of Public Finance, signed on July 13, 2021 a Transfer Letter related to the legal approach to the transfer of emissions, within the framework of the implementation of the Emissions Reduction Program, which has been analyzed by the Attorney General's Office on two occasions in 2021 and in 2022, to verify that there are no encumbrances in the emissions transfer process, which has been approved by the trustee on February 28, 2023

In accordance with the Letter of Transfer of Ownership of Emission Reductions signed by the Ministry of Public Finance on July 13, 2021, the MINFIN acting on behalf of the State of Guatemala, demonstrated its ability to transfer ownership of the Emission Reductions with based on: 1) The existing legal and regulatory framework; 2) The inter-institutional agreement for the implementation of the Emissions Reduction Program; 3) The models of sub agreements (contracts) to be signed with the holders of the REDD+ Initiative projects; and 4) reference to the provisions of the benefit sharing plan under the Benefit Sharing Plan.

The State of Guatemala through the Ministry of Public Finance -MINFIN- as the Entity of the Emissions Reduction Program -PRE- has the legal framework, duly issued, to hold said quality and this entity uses the execution of actions framed in a highly specific legal and technical framework that is developed by the National Institute of Forests -INAB- which has its own Law that gives it its own legal personality and that within its administrative competence develops the constitutional mandate regulated in article 126 of the Political Constitution of the Republic of Guatemala, referring to the urgency of reforestation through the implementation of the principle of sustainable and sustainable use of forest resources.

And within the administrative competence of the INAB is the administration of the PINPEP and PROBOSQUE forest incentives, which constitute a very effective means for the beneficiaries of such incentives to obtain a return for the fulfillment of certain technical actions supervised by the INAB and that indirectly provide extremely important environmental services for the population in general, which fall within articles 1,2,5 and 6 of Decree of the Congress of the Republic of Guatemala number 101-96 "Forest Law" and that such incentives provide the technical bases of the process or mechanism for the implementation of the emission reduction program; since such forestry incentive projects provide the bases for the mechanism or process for certification of emission reductions for their subsequent transfer, from INAB to MINFIN or directly to the Carbon Fund.

The Benefit Sharing Plan requires that in order to be eligible for the benefits and before the distribution of the benefits of the ERPAs, sub-agreements (contracts) must be signed by the holders of REDD+ Initiatives Projects that include clauses for the transfer of ownership of the Emission Reductions generated in the REDD+ Initiative Projects to the State of Guatemala.

Therefore, the legal status and feasibility of the Program Entity to transfer ownership of the emission reductions generated within the framework of the Emissions Reduction Program -PRE-, as established in numeral 3 of annex 1 of the Agreements Emissions Reduction Payment for Tranches A and B, of the Emissions Reduction Program, is based on the aforementioned regulations and jurisprudence and also on the agreement signed between the MINFIN and the INAB.

Each of the REDD+ Initiatives Projects will sign a Participation and title transfer contract (sub agreement) for the Program Entity, thorough the Executing Entity, on behalf of the State of Guatemala, in order to formalize the transfer of all rights and titles over the ERs contracted from these projects that will be part of the Program, the (contracts) must include clauses of participation and transfer of titles within which will be stated: the term, the conditions for the payment or distribution of benefits, the responsibilities of the parties, the mechanism of transfer of titles, among others.

The number of Sub-agreements (contracts) that are expected to be signed in the monitoring period (2020) by the holders of the REDD+ Initiative Projects, type early projects and new REDD+ are 3, as described in the Reduction Program Document; In the case of MCEABs-type REDD+ Initiative Projects, since the number of sub-agreements (contracts) is related to the number of projects that are going to request to get into the program and get approved by INAB, it is difficult to determine an exact number of sub-agreements (contracts) that will be signed; however, it is estimated that the number of projects and therefore the number of sub-agreements (contracts) will increase as the program progresses and the demand for participation increases. As a starting point, INAB has a goal of review and approve projects that sum at least 10,000 hectares in this category.

The number of Sub-agreements (contracts) that are expected to be signed for REDD+ Initiative Projects, such as Models for the conservation and sustainable use of forests in the SIGAP, is related to the projects that are going to request to get into the program and get approved by INAB and CONAP in protected areas. It is difficult to determine an exact number of sub-agreements (contracts) that will be signed; however, it is estimated that the number of projects and therefore the number of sub-agreements (contracts) will increase as the program progresses and the demand for participation increases.

Since REDD+ Initiative Projects can access to the program on demand, during the validity of the ERPA, the new contracts signed by them in the future, are going to be included in the second and third emission reduction report. I.e. contracts for the emission reductions of the monitoring period of 2020 are going to be included in the emission reductions monitoring report for the 2021-22 and 2023-2024 periods, and new contracts for the emission reductions of the monitoring period of 2021-2022 are going to be included in the emission reductions monitoring report for the 2023-2024 period, in order to transfer the titles of previous reporting periods.

6.2 Implementation and operation of Program and Projects Data Management System

Guatemala's Framework Law on Climate Change mandates MARN to create a National Climate Change Information System through Article 9 of the law. The SNICC will have a mitigation module in which the registry and monitoring of REDD+ initiative projects to be implemented in Guatemala will be housed (Including REDD+ Projects -Early and new-; Management Models for the Conservation and Sustainable Use of Forests in the SIGAP and Compensation Mechanisms for Ecosystem and Environmental Services Associated with Forests -MCSEABs-). This as well as the transparency mechanisms before the UNFCCC and the monitoring of the implemented measures. To consult the REDD+ project registry module and monitoring system, please click on the following LINK:

https://snicc.marn.gob.gt/Busqueda/Resultado?powerbi=https://app.powerbi.com/view?r=eyJrIjoiMmE4NjBlMDYtMmY5OS00YmMzLTljYmUtNzY4YzBjNTZlMDNlIiwidCI6IjhmYmFhNWJmLTJlY2MtNGRjOC1iNTZiLThmOTJlMzA3ZjA3NiIsImMiOjR9

The management of the information of the REDD+ Initiative Projects will be carried out through the management of files based on the processes and procedures established in the Operational Manual of the Benefit Distribution Plan, in the corresponding Regional, Subregional and central offices of the INAB.

During the period of this monitoring report, no emission reduction title transfers have been made. However, the country has developed, through its MOP Benefit Sharing Plan, the scheme and procedures to transfer emission reductions from future beneficiaries.

6.3 Implementation and operation of ER transaction registry

Under the Emissions Reduction Program, the country will use the World Bank's Carbon Asset Tracking System (CATS) as the official registry to carry out emission reduction transactions.

Additionally, through article 22 of Decree 7-2013 of the Congress of the Republic of Guatemala establishes that "the Ministry of Environment and Natural Resources, taking into account the proposals of the National Council on Climate Change created by this law, must issue the regulations necessary for the creation and operation of the Registry of Projects for the Removal or Reduction of Greenhouse Gas Emissions, for the procedures of disclosure, promotion, registration, validation, monitoring and verification of projects"

In order to avoid double counting of ERs, in the Emissions Reduction Program, the Project holders of the REDD+ Projects (Early and New), the MCSEAB and the Management Models for the conservation and sustainable use of forests in the SIGAP will be required by the Operative Manual of the BSP to register the certificates issued by INAB in the Registry of Projects for the Removal or Reduction of Greenhouse Gas Emissions, after the process of validation and verification of the monitoring reports.

In addition to the above, the REDD+ Projects Lacandon, Bosques para la Vida and Guatecarbon, according to the Guatemalan nesting protocol: All REDD+ initiatives currently registered under VERRA-VCS or future initiatives that potentially wish to register under various standards must register in the National Registry of REDD+ Initiatives of Guatemala. required by Art. 22 of (Decree No. 7-2013) as a commitment in the ER ownership transfer agreements.

6.4 ERs transferred to other entities or other schemes

In accordance with the negotiations carried out between the World Bank and Guatemala in the ERPAs, sweep contract volumes of Emission Reductions limits were established for REDD+ projects to be eligible to sell carbon certificates outside the ERPAs. For the first monitoring event, the sweep contract limit is 2.04 million tons of CO2eq, so projects that intend to sell excess emission reductions to the voluntary market and notify to INAB, in accordance with what established in the ERPAS and the Benefit Distribution Plan, can do it.

Currently there are two REDD+ projects that are within the project area, Lacandon[21] is fully located, while GUATECARBON[22] is partially located. Both projects have agreed to participate in the ERPA. As part of the ERPA negotiation process, an approach and nesting principles[23] for REDD+ initiatives in Guatemala were agreed upon. Once the verification process is completed, the tool developed for the implementation of this approach will be applied to each monitoring report in order to avoid double counting within the program. The nesting approach will be applied to new projects registered in the voluntary market.

7 REVERSALS

7.1 Occurrence of major events or changes in ER Program circumstances that might have led to the Reversals during the Reporting Period compared to the previous Reporting Period(s)

This section is not aplicable because this is the first monitoring period.

7.2 Quantification of Reversals during the Reporting Period

A.	**ER Program Reference level for this Reporting Period (tCO_2-e)**	*from section 4.1*		
B.	**ER Program Reference level for all previous Reporting Periods in the ERPA (tCO2-e).**	*from previous ER Monitoring Reports*		+

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[21] https://registry.verra.org/app/projectDetail/VCS/1541

[22] https://registry.verra.org/app/projectDetail/VCS/1384

[23] annex_xi-_approach_and_principles_of_nesting_redd_guatemala_09oct2020_clean.pdf

C.	Cumulative Reference Level Emissions for all Reporting Periods [A + B]		
D.	Estimation of emissions by sources and removals by sinks for this Reporting Period (tCO_2-e)	*from section 4.2*	
E.	Estimation of emissions by sources and removals by sinks for all previous Reporting Periods in the ERPA (tCO_2-e)	*from previous ER Monitoring Reports*	
F.	Cumulative emissions by sources and removals by sinks including the current reporting period (as an aggregate accumulated since beginning of the ERPA) [D + E]		
G.	Cumulative quantity of Total ERs estimated including the current reporting period (as an aggregate of ERs accumulated since beginning of the ERPA) [C – F]		
H.	Cumulative quantity of Total ERs estimated for prior reporting periods (as an aggregate of ERs accumulated since beginning of the ERPA)	*from previous ER Monitoring Reports*	
I.	[G – H], negative number indicates Reversals		
If I. above is negative and reversals have occurred complete the following:			
J.	Amount of ERs that have been previously transferred to the Carbon Fund, as Contract ERs and Additional ERs		
H.	Quantity of Buffer ERs to be canceled from the Reversal Buffer account [J / H × (H – G)]		

7.3 Reversal risk assessment

Risk factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting Reversal Risk Set-Aside Percentage

Default Risk	*N/P*	**10 %**	*N/P*	*10 %*
A. Lack of extensive and sustained support from the parties involved	*On October 12, 2021, the GoG officially launches the ER Program for the general knowledge of the population, causing interest in participating in said program, which in turn generates interest in both the public and private sectors to participate.* *Guatemala currently has more than 15 years of experience in the distribution of economic benefits through forestry incentive programs (PINFOR, PINPEP Law and PROBOSQUE Law). To date, the incentives granted amount to some USD 400 million directly to more than 525,000 users, and whose mechanism highlights the transparency of the process:* *i) INAB certifies compliance with forest management plans by users (beneficiaries),* *ii) The Ministry of Public Finance reviews and approves the files sent by INAB, and issues bank deposits directly to users and makes the payment of administrative expenses to INAB, and* *iii) The Comptroller General of Accounts, as an external entity, performs external audits of INAB to guarantee the transparency of the processes. In the specific case of the Lacandón Project, it has a governance committee and they have duly established that the GoG can sign agreements with Fundación Defensores de la Naturaleza (FDN, for its acronym in Spanish) for the transfer of ERs to the MINFIN and to the benefit distribution system, in a legal order in which all those involved have approved it and are informed.* *In the case of the beneficiary cooperatives of the* ***Lacandón - Forests for Life REDD+ Project****, they have agreed jointly with Fundación Defensores de la Naturaleza on the modality and rule for assigning the benefits of payment for project results. Beneficiary cooperatives will receive the equivalent of 55% of the benefits of payment for project results, of which 47% will be for incentives, 4% through the support received through the agriculture program and 4% in daily wages through the support received through forest protection. Likewise, cooperatives will carry out agricultural support activities for their members to promote conservation agricultural practices and increased productivity, which are considered non-monetary benefits.* *In the case of the forestry concessions represented by ACOFOP for the* ***GUATECARBON Project*** *in which they participate together with CONAP, they have an agreement in which CONAP recognizes as co-proponent and CONAP by the national legal system has the representation of the project.* *In the case of the* ***Local Networks for Development (REDDES) Project*** *coordinated by CALMECAC, the benefit distribution mechanism is under development as part of the project in general.* *Complaint mechanisms at the level of REDD+ projects and ER Program: The Mechanism for Information and*	**10%**	*The risk is considered a medium risk and has a discount of 5%, as presented in the ERP.*	*5%*

	Attention to Complaints (MIAQ, for its acronym in Spanish). In the development of the REDD+ Mechanism in its Preparedness phase, a REDD+ MIAQ was prepared, which will be strengthened after the signing of the ERPA. Its design ensures agility, access, quick response times and respect for confidentiality. This MIAQ, which will also be in charge of Gender-based Violence complaints (including special management procedures) and labor complaints, will be coordinated by INAB in association with MARN, and will be accessible -personally, anonymously or directly through a telephone line without cost, through the regional and departmental offices of INAB, MAGA, MARN and CONAP. Complaints, questions, or reports are expected to be resolved within 30 business days of receipt. *Although Guatemala has successful experiences in forest governance, benefit distribution and extensive REDD+ stakeholder involvement, it has been considered a "medium" risk due to discussions and decision-making to change the focus of the ER Program to sub-national level, given that: i) In the framework of the preparedness meetings, FUNDAECO has expressed its intention not to participate in the ER Program with the Carbon Fund of the FCPF, due to commitments acquired prior to the signing of the Letter of Intent; and, ii) The social conflict linked to evictions that occurred in the Laguna del Tigre National Park and the Candelaria Zone, which is important to highlight that they occurred outside the national REDD+ process.* *All REDD+ initiatives in any of their modalities must be entered into the national registry as established in Article 22 of the Framework Law on Climate Change for procedures for disclosure, promotion, registration, validation, monitoring and verification of projects.*			
B. Lack of institutional capacity or ineffective vertical/cross-sectoral coordination	*Guatemala has more than 15 years of experience in inter-institutional coordination for the forestry sector, which is made up of two main institutional governance platforms that have allowed coordination between institutions and sectors (public, private, municipalities, academia, NGOs, etc.) for the design and implementation of public policies for the sector. These are: i) The INAB Board of Directors made up of representatives from the public sector (MAGA and the Ministry of Public Finance), private sector (Chamber of Industry and Forestry Association), local governments (ANAM), NGOs and academia (National Central School of Agriculture and Universities that teach forestry and related studies within related professions); and, ii) The National Council for Protected Areas (CONAP) with representation from the central government (MARN, MAGA, MCD/INAH INGUAT), local governments (National Association of Municipalities –ANAM-) and NGOs. Both INAB and CONAP have regional offices (9 and 10, respectively) to fulfill their mandate in accordance with the administrative structure of the State and in coordination with their different partners.*	**10 %**	*No change has occurred so far, it's low and a 10% discount applies, as stated in the ERPD.*	*0%*

	Through this instance, the implementers have representation from the national level, in which it is considered for the Board of Directors of INAB, with a chair within the Board that belongs to the ASOREMA (National Association of Non-Governmental Organizations of Natural Resources and Environment), of which the implementers are part and they have also occupied the chair of this organization within the Board of Directors. Likewise, within the National Council for Protected Areas (CONAP), the environmental NGOs registered in the CONAP have a position that is elected in an assembly, in which the latter have also had the representation of the implementers of REDD+ projects. *At the local level, in the case of the Sierra de las Minas Biosphere Reserve, which is a protected area that includes the territory of 14 Guatemalan municipalities, distributed in 5 departments, whose Secretary of the Board is held by Fundación Defensores de la Naturaleza, and is chaired by CONAP, the same happens in the Sierra del Lacandón National Park. In the case of Petén, in addition to the MBR Committee, there is a Committee for Laguna del Tigre, the latter established in a specific Law with the participation of both committees of implementers such as ACOFOP and Fundación Defensores de la Naturaleza. This is how, in this way, participation according to national and local governance play a role as articulators of work to improve coordination processes.* *It is important to mention that these instances have coordinated actions for the conservation of the natural forest, establishment of forest plantations and land, under productive forest management, which represents a better protection of water and soil, benefiting more than 3.9 million people, while the rural economy has improved.* *Similarly, the GCI, established since 2012 (MARN, MAGA, INAB and CONAP), has been the inter-institutional platform that has facilitated coordination linked to REDD+ and which is based on an inter-institutional agreement signed in May 2015. This agreement allows articulate efforts of institutions that, in turn, in Article 20 of the Framework Law on Climate Change, mandates these institutions to adjust and design policies, strategies, programs, plans and projects for the reduction of emissions in the forestry sector and climate change of land use.* *This platform has allowed the articulation of institutions, from the GCI and external ones, for the implementation of projects such as the ER-PIN and project proposals before the NAMA Facility.* *Additionally, there are multisectoral platforms for coordinating actions such as: a) The Workgroup for the Prevention and Reduction of Illegal Logging; b) the Firewood Workgroup in which the Strategy for Sustainable Production and Efficient Use of Firewood is coordinated; and, c) the Restoration Workgroup, in*			

	which the National Forest Landscape Restoration Strategy is coordinated. *The participation of the Ministry of Public Finance leading the ER Program has been strategic both at the level of inter-institutional and sectoral coordination, as well as for the alignment of the program with the country's public policy priorities.*			
C. Long-term ineffectiveness in managing underlying drivers	*The Law of Protected Areas and its regulations create the SIGAP that houses 340 protected areas that cover just over 32% of the national territory. It establishes, among others, the conservation, rational management and restoration of wild flora and fauna, related resources and their natural and cultural interactions, as well as guidelines for preparing Management Plans that articulate Annual Operational Plans and sub-zoning. Likewise, CONAP has, through Decree 5-90 for the creation and setting of limits of the Mayan Reserve in Petén, which establishes a Coordinating Committee of the Mayan Reserve constituted by CONAP, other government agencies that co-manage and participation of civil society, for surveillance and also strategies that, up to today, have allowed to analyze in this governance scheme, the strategies that have allowed implementing actions based on the best possible management of Forest Concessions, early warning systems against forest fires in communities within the Reserve, as well as joint patrols to identify threats to the integrity of Natural Resources. The GoG, through the CONAP Secretariat, has begun coordination to extend the term of forest concessions in the north of the country. This minimizes the pressure on the tropical forest.* *The Forestry Law contemplates policy tools to seek harmonization between the management and protection of the forest and the economic activities linked to the drivers, for example, livestock, basic grains and other crops such as coffee, among others. Under this framework, the Forestry Incentives Program (PINFOR, for its acronym in Spanish) was created, which ended in 2016, the PINPEP Law, which is the Forestry Incentives Program for owners of small extensions of land for forestry or agroforestry (aimed at people who own plots of land with an extension smaller than 15 ha by paying them to plant trees or manage natural forests), and in 2017 the PROBOSQUE Law that gives continuity to the PINFOR Incentive Program and also expands the type of beneficiaries, ensuring the granting of forestry incentives for another 30 years and, with it, contributing to the management and conservation of forest resources with the participation of municipalities, indigenous communities, associations, the private sector, among others.* *Through PINFOR, during the period from 1998 to 2016, the State of Guatemala spent GTQ 1,942,907,687 (USD 255 million) for forestry incentives, for a total of 10,418 projects, equivalent to 383,568 hectares of reforestation (36%) and forest management of natural forests (64%), whose beneficiaries are divided into nine groups called*	**5 %**	*No change has occurred so far, it is medium and a 2% discount is applied*	*3%*

	"Types of Owners." These are: i) Associations; ii) Committees; iii) Communities; iv) Cooperatives; v) Companies; vi) Foundations; vii) Individuals; viii) Municipalities; and, ix) Government Organizations. This, in addition to revitalizing the local economy, has contributed economically in vulnerable areas of Guatemala, which leads to a reduction in the pressure exerted on the forests and their value enhancement. *With the PINPEP Law, during the period from 2007 to 2016, the State of Guatemala derogated Q 634,804,592.45 (about USD 85.5 million) for forestry incentives, for a total of 25,745 projects, equivalent to 91,641.54 hectares of reforestation (15%) and management of natural forests (85%), whose beneficiaries are divided into nine groups called "Types of Owners." These are: i) Associations; ii) Committees; iii) Communities; iv) Cooperatives; v) Companies; vi) Foundations; vii) Individuals; viii) Municipalities; and, ix) Government Organizations.* *With the PROBOSQUE Law, it is expected that during 2017-2046 the establishment, recovery and management of:* *• Establishment of 200,000 ha of forest plantations for industrial purposes.* *• Establishment and maintenance of 100,000 ha of forest plantations for energy purposes.* *• Establishment and maintenance of 300,000 ha of agroforestry systems.* *• Management of 125,000 ha of natural forest for production purposes.* *• 375,000 ha of natural forest for the purpose of protection and provision of environmental services.* *• Restoration of 200,000 ha of degraded forest land.* *• Despite these achievements, all the underlying factors of deforestation and forest degradation have not yet been addressed, since these forestry incentive programs, inside and outside protected areas, have a maximum duration of up to 10 years, but after this period there is no incentive for users to avoid changing the use of the forest. However, this is sought to be addressed through the Forest Investment Program (FIP), which is part of the ER Program.*			
D. Exposure and vulnerability to natural disturbances	*In the case of effective prevention of natural disturbances or mitigation of their impacts, Guatemala has a National Response Plan, a National Protocol for the Comprehensive Management of Disaster Risk due to Extended Dry Spell for the Republic of Guatemala, and the National Protocol for the Season of Temperature Decrease in the Republic of Guatemala 2018-2019. The country has not shown sufficient capacity for the effective prevention and mitigation of impacts associated with natural phenomena. This is reflected in the economic losses that the country has suffered in strategic sectors due to floods and droughts associated with climate change. According to ECLAC (2012), in the last 3 decades, the economic impacts associated with hydrometeorological phenomena amount to almost USD*	**5 %**	*No change in risk, as stated in the ERPD.*	*5%*

	3,500 million, impacting mainly on the agriculture and infrastructure sectors. If ambitious and immediate goals are not established and achieved, ECLAC (2018) estimates that the economic cost by 2030 would be equivalent to 5.8% of the GDP (annual average). *Hurricanes Eta and Iota arrived in Guatemala as tropical depressions, and the rains, floods and landslides associated with these events had a significant impact on the population, especially in the most vulnerable communities in Guatemala. The majority of affected people reside in rural areas, self-identify as belonging to indigenous peoples, and live in levels of poverty due to their income and multidimensional poverty below the national average. In economic terms, it is estimated that the total effects of these tropical depressions were equivalent to approximately 6,002 million quetzales. Damages accounted for 52% of the impact; losses, to 31%; and, additional costs, 17%. The economic impact of these events is estimated at 0.1 percentage points of the GDP. These disasters also occurred in the context of COVID-19. All of this, together, has serious consequences in the short and medium term. Disasters are an opportunity to rethink the development of countries and this assessment is a contribution in that direction, with a development approach focused on resilience and inclusion, which, in a context of increasing risk of disasters caused by climate change, will allow Guatemala to get closer to the achievement of the Sustainable Development Goals. (ECLAC, 2021)* *Although the GoG has a legal framework for protection against forest fires, the country does not have sufficient capacity for their effective prevention and mitigation. The following are included within the Legal Framework:* *• Constitution of the Republic (Articles 64, 97, 119 and 126), the Law of the Executive Branch (Decree 114-97, Articles 29, 29bis, 37 and 47);* *• Framework Law on Climate Change (Articles 1, 2, 3, 4, 5, 6, 7, 9, 13, 14, 15 and 23);* *• Constitutive Law of the Guatemalan Army (Decree 72-90, Article 4);* *• Municipal Code (Decree 12-2002, Articles 33, 35, 58, 67, 68 and 96);* *• Forest Law (Decree 101-96, Articles 1, 4, 6, 8, 36, 37, 38 and 93);* *• PROBOSQUE Law (Decree 2-2015);* *• PINPEP Law (Decree 51-2010);* *• Law of Protected Areas (Decree 4-89, Articles 1 and 4);* *• Law of the National Coordination Office for Reduction of Natural or Caused Disasters (Decree 109-96, Articles 1, 3, 4, 6, 9, 10 and 21);* *• Government Agreement 156-2017 (Decree 101-96, Articles 1, 4, 6, 8, 36, 37, 38 and 93);* *• Forestry Law Regulations, Board of Directors Resolution 01.43.2005 (Articles 33, 37, 38, 39, 52 and 88).*			

	Likewise, the National Protocol for the Forest Fire Season 2018-2019 of the National Coordination Office for Disaster Reduction (CONRED, for its acronym in Spanish) was approved, which establishes guidelines for the prevention, preparedness and control against forest fires, as part of the tools of public policy and which is applicable to all centralized and decentralized government institutions. In addition, in its preparedness section, it establishes strategies and tactics regarding the fire season. *According to the historical recurrence of hot spots 2003-2017, forest fires in the MBR are probably the greatest threat to the integrity of this area, whose highest peaks have coincided with prolonged droughts. Regarding natural disturbances, Guatemala presents high vulnerability to climatic phenomena (storms, droughts), going from a moderate level of climatic vulnerability in the year 2010 to a high level, for the year 2030. It is estimated that 59% of the events recorded in the period 1900-2015, were climatic events (storms and hurricanes, landslides, floods, droughts and extreme temperatures), causing monetary losses of up to USD 4,421 million.* *In the area of forest concessions, there are positive experiences that demonstrate the effectiveness in controlling forest fires (this is regulated in each of the Concession Contracts). It is necessary to reinforce the control and surveillance of forest fires in some territories, but mainly those associated with an anthropogenic origin.* *During the monitoring period, the risk of droughts and forest fires was low.*			
		Total Reversal Risk Set-Aside Percentage		*23%*
		Total Reversal Risk Set-Aside Percentage of the Document for the Reduction of Emissions or the previous Monitoring Report (whichever is more recent)		*23%*

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

A.	**Emission Reductions during the Reporting period (tCO_2-e)**	*from section 4.3*	9,237,210
B.	**If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)**		0
C.	**Number of Emission Reductions estimated using measurement approaches (A-B)**		9,237,210
D.	**Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested**	*from section 6.1*	100
E.	**ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes**	*from section 6.4*	0
F.	**Total ERs (B+C)*D-E**		9,237,210
G.	**Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period**	*from section 5.2*	12
H.	**Quantity of ERs to be allocated to the Uncertainty Reversal Buffer (0.15*B/A*F)+(G*C/A*F)**		1,108,465
I.	**Total reversal risk set-aside percentage applied to the ER program**	*from section 7.3*	23%
J.	**Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)**		1,463,174
K.	**Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*5%**		406,437
L.	**Number of FCPF ERs (F- H – J – K)**		6,259,134

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

This section of the Monitoring Report for the 2020 period is intentionally left blank, considering that the content of annexes 1, 2 and 3 is currently undergoing a process of completion and review parallel and independent of carbon accounting through specialists. of the world bank on safeguards.

Upon having the corresponding approvals of annexes 1, 2 and 3, this content will be incorporated into the structure of the monitoring report.

ANNEX 2: INFORMATION ON THE IMPLEMENTATION OF THE BENEFIT-SHARING PLAN

This section of the Monitoring Report for the 2020 period is intentionally left blank, considering that the content of annexes 1, 2 and 3 is currently undergoing a process of completion and review parallel and independent of carbon accounting through specialists. of the world bank on safeguards.

Upon having the corresponding approvals of annexes 1, 2 and 3, this content will be incorporated into the structure of the monitoring report.

ANNEX 3: INFORMATION ON THE GENERATION AND/OR ENHANCEMENT OF PRIORITY NON-CARBON BENEFITS

This section of the Monitoring Report for the 2020 period is intentionally left blank, considering that the content of annexes 1, 2 and 3 is currently undergoing a process of completion and review parallel and independent of carbon accounting through specialists. of the world bank on safeguards.

Upon having the corresponding approvals of annexes 1, 2 and 3, this content will be incorporated into the structure of the monitoring report.

ANNEX 4: CARBON ACCOUNTING - ADDENDUM TO THE ERPD

Technical corrections

Technical corrections applied to the reference level of the program.

The corrections to the reference level were in the order of the improvement of the emission factors of the non-forest classes corresponding to numeral 1 (Improvement of emission factors) of the Methodological Framework Number 2 [24]. The emission factors were updated due to the refinement of the 2019 IPPC guidelines that update the values of the guidelines that were in place for 2006.

Also, the improvement in the activity data of the reference level corresponding to numeral 2 (Improvement to activity data) of the Methodological Framework Number 2 was made, since more high-resolution images and quality control processes were available.

Derived from the collection of activity data for the first reporting period of the program and the presentation of a reference level before the United Nations Framework Convention on Climate Change (UNFCCC), a review of the samples that had non-logical changes was made as part of a QA/QC process. Land cover information was updated by identifying non-logical changes within the 2006-2016 reference level period.

Likewise, a review was also made of the non-forest carbon content using the IPCC refinement guidelines for 2019, in which the carbon content values for agricultural crops, agricultural land for coffee, rubber, palm, and agroforestry systems were updated.

It was also considered that, for the recovery of the forest area, the proportion of carbon that is recovered annually and not the total carbon was calculated.

Start Date of the Crediting Period

Start date of the credit period

The date of the credit period is from January 1, 2020 to December 31, 2024.

According to the ERPAs, section 6.0.1, the start date of the program is January 1, 2020, and the first monitoring period is from 01/01/2020 to 12/31/2020[25].

The date complies with the following conditions:

1. It is not earlier than the date the first ER Program Measure(s) (including any SubProject(s)) begins generating ERs, i.e. first implementation: Section 4.3.1 of the ERPD lists all the programs that support REDD+ implementation (PROBOSQUE, PINPEP, etc.) which have been implemented in the years prior to the start of the ERPD (2010 and 2015).

2. It is justified with objective evidence by the ER Program Entity and it is independently assessed by a Validation Verification Body during validation. The images used during the visual interpretation process for the PM

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[24] https://www.forestcarbonpartnership.org/system/files/documents/fcpf_guidelines_on_the_application_of_the_methodological_framework_number_2_2020_0_0.pdf

[25] fcpf_erpa_tranche_a_-_b_-_guatemala.pdf (forestcarbonpartnership.org)

correspond to 01/01/2020 and in case there were no images available at the date of interest, the closest image to the date of interest was sought.

3. It is not earlier than January 1st 2016: Yes, it is fulfilled due to the fact that the program begins on January 1, 2020

4. It does not fall within the Reference period: There is no conflict with the reference level because the period starts on January 1, 2020. The reference period covers 2006-2016.

5. It is demonstrated that the ER Program complies with requirements since the start date on safeguards, carbon accounting and double-counting as specified in the MF. See Annex 1, Annex 4, Chapter 3 and 4 of this report.

7. Carbon pools, sources and sinks

7.1 Description of Sources and Sinks selected

Sources/Sinks	**Included?**	**Justification/Explanation**
Emissions from deforestation	*Yes*	At a minimum, ER Programs must account for emissions from deforestation.
Emissions from forest degradation	*Yes/no*	
…		

Sources/sinks	**Included?**	**Rationale/explanation**
Deforestation	Yes	All area of classifications and forest land changing to other non-forest land.
Degradation	Yes	All area of forest land classifications remaining as forest land and losing between 30% and 70% of forest cover.
Carbon stock increases	Yes	Area that belongs to other non-forest land and is converted to forest plantations and the restoration of degraded areas: Area of forest land that remains and gains between 30% and 70% forest cover.

7.2 Description of carbon pools and greenhouse gases selected

Carbon stocks	**Selected?**	**Justification/Explanation**
Above-ground biomass (AGB)	*Yes*	This is the most significant pool, which includes above-ground biomass carbon of trees greater than 10 cm in diameter, measured at 1.3 m (DBH). The data of this pool is modeled in the map of carbon strata at the national level, which was prepared from 2,306 plots of forest inventories, from different projects, which were systematized, refined, standardized and analyzed to obtain the value of biomass for each individual greater than 10 cm DBH. General allometric equations were applied, differentiating broadleaf forests in Petén, coniferous forests, broadleaf forests and mangrove forests; in the latter, three species-specific equations were used. The factor of 0.47 was used to convert biomass into carbon and the result per hectare was standardized by dividing the result by the size of the plot, except for the forests of Petén, the factor 0.5 was used according to a study by Arreaga 2002.
Below-ground biomass (BGB)	*Yes*	This pool is related to the previous one and biomass below the ground (roots) is included, using an equation for the Petén, coniferous and broadleaf forests, which represents a relationship based on the proportion

		of above-ground biomass. For the mangrove forest, three specific equations were used for the species found in that place.
Leaf litter	*No*	There are no data for all types of forest in the country and, using partial data, it is estimated that emissions represent 5.6% of total emissions from deforestation and degradation.
Soil organic carbon (SOC)	*No*	There are no data for all types of forest in the country and, using partial data, it is estimated that emissions **represent 5.54% of total** emissions from deforestation and degradation.

GHG	Selected?	Justification/Explanation
CO2	*Yes*	Emissions and absorptions in tons of CO_{2eq} for all the aforementioned activities are included.
Other GHGs	*No*	For the 2006-2016 period, there are preliminary estimates based on tabular data of fires of emissions of CH4 and N2O 24,556.51 tCO_{2eq}/year from forest fires, which represents less than 1% of total emissions.

8. Reference Level

8.1 Reference Period

The FREL is based on GHG emissions at the subnational level in the area of the emission reduction program, in the historical period from 2006 to 2016, accounting for CO_{2eq}, for emissions in deforestation and degradation, and removals of CO_{2eq} for the increase in carbon stocks. This period has 2016 as its end year in compliance with criterion 11 of the methodological framework, and covers a historical period of 10 years accounting for GHG emissions and absorptions from 2007. The FREL is under an emissions reduction agreement with the FCPF for a period of 5 years.

In a previous version for the period 2000-2010, estimates are made from fire scars, assuming that all fires consume tree biomass; so, the data differ from these new estimates. The period comprises 10 years since the initial forest cover is identified in 2006 and changes that imply emissions are identified until the following year.

The activity data information on coverage and dynamics is generated with a sampling based on a systematically-distributed grid for the entire country in a multi-temporal analysis in the time period 2006-2016, from medium and high resolution satellite images.

In the national grid and in the program area, in the historical period of the FREL, the change of use is determined due to the loss of forest land, degradation due to the loss of forest cover in areas that remain as forest land, and the increase in the area with commercial forest plantations on land that was previously not forested, according to the national definitions described in the next section.

8.2 Forest definition used in the construction of the Reference Level

According to the national definition, the forest is the continuous area with dominant tree cover[26] with a minimum canopy cover of 30%, forming a stand of a minimum of 0.5 hectares and a minimum width of 60 meters (GIMBUT 2018b). Forests and other land uses are defined below in the consistent representation of land with its classification criteria, to provide greater clarity in the quantification of the FREL, as well as in the characterization of the forest land dynamics processes that are identified from REDD+ activities in the FREL.

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[26] Tree: Woody plant with a defined stem and crown with secondary growth that, when mature, reaches a minimum height of 5 meters and a minimum diameter of 10 cm.

The definition of forest used differs from that used in the Forest Report Assessment (FRA) 2015, which is as follows: *Forest land or land without any use that extends over 0.5 hectares, endowed with trees that reach a height greater than 5 m and a canopy cover greater than 10 percent. The term specifically excludes tree stands used in agricultural production systems, for example fruit plantations and agroforestry systems. The term also excludes trees that grow in urban parks and gardens.*

On the other hand, the GHGI presented in the Third National Communication on Climate Change does not include a definition of forest, nor does it include the input used to detect deforestation. However, it can be assumed that operationally it should be similar due to the forest classifications identified, as well as to the other uses that are reported.

Although there could be differences in the definitions, operationally the definition has remained constant, since the classifications and figures reported in terms of the amount of forest, both in the FRA and in the National Communication are similar, and the differences can be attributed to the use of different inputs and methodologies, rather than to a difference in definition. In addition, the definition presented in this document will be used in the next official reports to the UNFCCC.

8.3 Average annual historical emissions over the Reference Period

Description of method used for calculating the average annual historical emissions over the Reference Period

Annual historical average of emissions during the Reference Period

The land use approach, in the three REDD+ activities of deforestation, degradation and increases in forest carbon stocks (IPCC, 2006). CO_{2eq} emissions and removals were obtained by multiplying the activity data corresponding to the area converted from forest land to other land for deforestation, the forest land that remains as forest land that loses coverage due to degradation, and the other land that is converted to forest land, through the recovery of degraded areas and the establishment of forest plantations to increase carbon stocks, by emission and absorption factors (Equation 8, which corresponds to the calculation section).

$$\mathbf{RL=(Def+deg)-(Incr) = (E_{DEF}+E_{DEG}) - (R_{rec}+R_{pla}) = ((ADef * FE) + (ADdeg * FE) - (Rrec * FA) - (Rpla * FA))}$$

Where:

$\mathbf{RL}$ = Reference Level
$\mathbf{E_{DEF}}$ = Emissions from Deforestation
$\mathbf{E_{DEG}}$ = Emissions from degradation
$\mathbf{R_{rec}}$ = Removals from forest degradation recovery
$\mathbf{R_{pla}}$ = Removals due to increased carbon through forest plantations
$\mathbf{AD}$ = Activity data for conversion of forest lands to other lands (Deforestation), permanent forest lands with forest cover loss (Degradation), and degraded permanent forest lands that increase their forest cover and establishment of forest plantations (Increases).
$\mathbf{FE}$ = Emission factors for deforestation and degradation.
$\mathbf{FA}$ Absorption factors for carbon increases in forest biomass.

To determine the emissions of the reference level, the first step is to calculate the information from the activity data and then make the estimate in tons of CO_2 equivalent.

Below you will find the links to the files to estimate the activity data, as well as the emissions and removals of the reference level.

- File containing the estimates of emissions and removals for each of the REDD+ activities:

- File that contains the information of the point grid with its categories of land use:

Guatemala does not consider the annual loss of biomass due to forest removal (harvesting), the collection of fuel wood and other losses caused by disturbances, storms, insects and forest and diseases. The estimates for each activity are made separately with specific assumptions based on the information available, and their methods of obtaining activity data and their emission and absorption factors.

Activity data and emission factors used for calculating the average annual historical emissions over the Reference Period

Activity data

<table>
<tr><td>Parameter:</td><td>Deforestation</td></tr>
<tr><td>Description:</td><td>Forest land converted to non-forest uses
The following equations were used to calculate this parameter:
Activity data: Equation 3
Additionally, to convert the data to emissions we used equation 8.</td></tr>
<tr><td>Data unit:</td><td>Hectares</td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link
The interpreters who performed the interpretation and after labeling the 11,369 and labeling the change, a filter was made to identify those points that were deforestation within the program area. A total of 287 points were identified within the program area, to then use the equation found in section 2.1.1 to obtain the data on hectares of deforestation.
The table of applied values shows the main transitions caused by deforestation.
The total number of hectares deforested at the reference level was 275,202.79 ha.
The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link
In the NR Program tab and column D of the deforestation section (Rows 5-40) is the information corresponding to the activity data of the reference level. The information in this column is not divided into the years corresponding to the reference level.</td></tr>
<tr><td>Value applied</td><td><table><tr><th>Category</th><th>Ha</th></tr></table></td></tr>
</table>

Forest I to agricultural land	7,671.16
Forest II to agricultural land	19,177.89
Forest III to agricultural land	9,588.95
Forest IV to agricultural land	6,712.26
Forest I to agricultural-brown lands	-
Forest II to agricultural-brown lands	2,876.68
Forest III to agricultural-brown soils	-
Forest IV to agricultural-brown lands	958.89
Forest I to agricultural lands-African palm	1,917.79
Forest II to agricultural lands-African palm	8,630.05
Forest III to agricultural soils-African palm	1,917.79
Forest IV to agricultural lands-African palm	-
Forest I to agricultural land-rubber	-
Forest II to agricultural land-rubber	958.89
Forest III to agricultural soils-rubber	1,917.79
Forest IV to agricultural land-rubber	1,917.79
Forest I to agroforestry systems	1,917.79
Forest II to agroforestry systems	3,835.58
Forest III to agroforestry systems	2,876.68
Forest IV to agroforestry systems	3,835.58
Forest I to grasslands	79,588.26
Forest II to grasslands	71,917.11
Forest III to grasslands	31,643.53
Forest IV to grasslands	5,753.37
Forest I to settlements	1,917.79
Forest II to settlements	958.89
Forest III to settlements	-
Forest IV to settlements	958.89
Forest I to other lands	-
Forest II to other lands	2,876.68
Forest III to other lands	958.89
Forest IV to other lands	958.89
Forest I to wetlands and bodies of water	958.89
Forest II to wetlands and bodies of water	-
Forest III to wetlands and bodies of water	-
Forest IV to wetlands and water bodies	-

QA/QC procedures applied:	A review of the non-logical changes was made and the information corresponding to the land cover that did not match was updated. For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.

<table>
<tr><td>Uncertainty associated with this parameter:</td><td>
<table>
<tr><th>Classification</th><th>Deforestation</th></tr>
<tr><td>Median</td><td>44,951.1</td></tr>
<tr><td>Average</td><td>45,032.8</td></tr>
<tr><td>Deviation</td><td>42,905,355.4</td></tr>
<tr><td>CI – lower limit</td><td>32,024.6</td></tr>
<tr><td>CI – upper limit</td><td>58,084.9</td></tr>
<tr><td>%</td><td>29.0</td></tr>
</table>
</td></tr>
<tr><td>Any comment:</td><td>To access the documents and calculations related to this activity, consult the following link:
Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link</td></tr>
</table>

Parameter:	Degradation
Description:	Degraded forest land The following equations were used to calculate this parameter: Activity data: Equation 4 Additionally, to convert the data to emissions we used equation *9*.
Data unit:	Hectares
Source of data and description of measurement/calculation methods and procedures applied:	To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez For degradation, the three interpreters identified a total of 200 points within the four forest strata that were identified for Guatemala. Of these 200 points, 36 correspond to Stratum 1, 87 to Stratum II, 54 to Stratum III and finally 23 to Stratum IV. This corresponds to a total of 51,495 hectares that were degraded during the reference level period. This analysis is performed on forest land that is maintained as such. To identify plots with forest degradation, the following equation is used:

<table>
<tr>
<td></td>
<td>

$$Degradation = 100 * \frac{Year\ 2016 * 100}{Year\ 2006}$$

The analysis is done at the grid points, which remain as forest land or forest. Subsequently, the analysis of the loss of the elements that were categorized as trees is made. If the point loses between 30% and 70% of the trees, it is categorized as forest degradation.

The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".

https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

In the NR Program tab and column D of the degradation section (Rows 45-48) is the information corresponding to the activity data of the reference level. The information in this column is not divided into the years corresponding to the reference level.
</td>
</tr>
<tr>
<td>Value applied</td>
<td>
Table 31. Average hectares per year that have been degraded within the 2006-2016 period
<table>
<tr><th>Classification</th><th>(Ha)</th></tr>
<tr><td>Forest I (>70%) to degraded (70-30%)</td><td>34,520.21</td></tr>
<tr><td>Forest II (>70%) to degraded (70-30%)</td><td>83,423.84</td></tr>
<tr><td>Forest III (>70%) to degraded (70-30%)</td><td>51,780.32</td></tr>
<tr><td>Forest IV (>70%) to degraded (70-30%)</td><td>22,054.58</td></tr>
</table>
</td>
</tr>
<tr>
<td>QA/QC procedures applied:</td>
<td>For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</td>
</tr>
<tr>
<td>Uncertainty associated with this parameter:</td>
<td>
Table 32. Uncertainties of degradation in the monitoring period
<table>
<tr><th>Classification</th><th>Degradation</th></tr>
<tr><td>Median</td><td>84,301.2</td></tr>
<tr><td>Average</td><td>84,214.0</td></tr>
<tr><td>Deviation</td><td>80,521,353.3</td></tr>
<tr><td>CI – lower limit</td><td>66,956.1</td></tr>
<tr><td>CI – upper limit</td><td>102,067.1</td></tr>
<tr><td>%</td><td>20.8</td></tr>
</table>
</td>
</tr>
<tr>
<td>Any comment:</td>
<td>To access the documents and calculations related to this activity, consult the following link:</td>
</tr>
</table>

	Activity data: https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link Calculation of hectares and emissions/absorptions https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

Parameter:	Forest Degradation Recovery
Description:	Land recovered from forest degradation The following equations were used to calculate this parameter: Activity data: Equation 5 Additionally, to convert the data to emissions we used equation 10.
Data unit:	Hectares per year
Source of data and description of measurement/calculation methods and procedures applied:	To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez To calculate the recovery from degradation, a total of 121 points were identified in the four forest strata of the program. Of these 121 points, 33 correspond to Stratum I, 37 to Stratum II, 33 to Stratum III and 18 to Stratum IV. The total hectare per year for the reference level was 40,939 hectares. It is important that this analysis is done within the points that maintain their forest cover, and that recover 30% to 70% of the elements corresponding to trees. To carry out this analysis, the following equation is used: $Degradation\ recovery = 100 * (\frac{Year\ 2006 * 100}{Year\ 2006})$ After knowing the total number of points that were identified as recovery from degradation, the equation found in section 2.1.3 was used to obtain the data in hectares, and then divided by two years to obtain the data in hectares per year. The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir". https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

<table>
<tr><td></td><td>In the NR Program tab and column D of the degradation section (Rows 49-52) is the information corresponding to the activity data of the reference level. The information in this column is not divided into the years corresponding to the reference level.

After the calculation, the carbon content value corresponding to the stratum in which the plot is located is assigned, using the table shown below:</td></tr>
<tr><td>Value applied</td><td>Table 33. Hectares of forest increments through forest restoration.
<table>
<tr><th>Classification</th><th>(Ha)</th></tr>
<tr><td>Forest I restored</td><td>31,643.53</td></tr>
<tr><td>Forest II restored</td><td>35,479.11</td></tr>
<tr><td>Forest III restored</td><td>31,643.53</td></tr>
<tr><td>Forest IV restored</td><td>17,260.11</td></tr>
</table></td></tr>
<tr><td>QA/QC procedures applied:</td><td>For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>Table 34. Restoration uncertainties of degraded areas
<table>
<tr><th>Classification</th><th>Restoration</th></tr>
<tr><td>Median</td><td>204,288.9</td></tr>
<tr><td>Average</td><td>204,262.6</td></tr>
<tr><td>Deviation</td><td>190,715,024.6</td></tr>
<tr><td>CI – lower limit</td><td>176,772.0</td></tr>
<tr><td>CI – upper limit</td><td>232,084.8</td></tr>
<tr><td>%</td><td>13.5</td></tr>
</table></td></tr>
<tr><td>Any comment:</td><td>To access the documents and calculations related to this activity, consult the following link:
Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link</td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>Increased Carbon Through Forest Plantations</td></tr>
<tr><td>Description:</td><td>Increased Carbon Through Forest Plantations
The following equations were used to calculate this parameter:
Activity data: Equation 6
Additionally, to convert the data to emissions we used equation 11.</td></tr>
<tr><td>Data unit:</td><td>Hectares</td></tr>
</table>

Source of data and description of measurement/calculation methods and procedures applied:

Regarding the information on forest plantations for the reference level, a total of 29 points corresponding to this activity were identified, of which 13 points correspond to coniferous plantations and 16 points correspond to broadleaf plantations. The total hectare per year for the reference level was 14,285 hectares.

The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".

https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

In the NR Program tab and column D of the degradation section (Rows 53-54) is the information corresponding to the activity data of the reference level. The information in this column is not divided into the years corresponding to the reference level.

Value applied

Table 35. Hectares of carbon increases through forest plantations.

Classification	(Ha)
Profit Coniferous Plantations	12,465.63
Profit Broadleaf Plantations	15,342.32

QA/QC procedures applied:

For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.

Uncertainty associated with this parameter:

Table 36. Forest plantation uncertainties

Classification	Plantations
Median	973.8
Average	977.6
Deviation	907,138.1
CI – lower limit	- 916.5
CI – upper limit	2,853.4
%	193.6

Any comment:

To access the documents and calculations related to this activity, consult the following link:

Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

Emission factors

Parameter:	**Forest carbon content (Cfor)**
Description:	Forest carbon content of four carbon strata before conversion to non-forest land Used in the equations:8, 9,10,18,19,20
Data unit:	Ton of carbon per hectare
Source of data and description of measurement/calculation methods and procedures applied:	The information generated in the carbon strata map of Guatemala was used to establish biomass above and below ground for forest information. To obtain the carbon content, a study was carried out in which a total of 2,037 forest plots were analyzed, which was prepared by the National Council of Protected Areas with the support of GIMBUT. To obtain greater clarity on how the forest carbon content in Guatemala was constructed, the documents, databases and spatial data have been placed in the section of any comments. The most significant pool includes above-ground biomass carbon from trees greater than 10 cm in diameter (Trees greater than 10 cm DBH[27] are included, because for Guatemala it is the definition of a tree) measured at 1.3 m (DBH). The data of this pool is modeled in the carbon strata map at the national level, which was prepared from 2,307 plots of forest inventories, from different projects, which were systematized, refined, standardized, and analyzed to obtain the value of biomass for each individual greater than 10 cm DBH[28]. The data of this pool is modeled in the carbon strata map at the national level, which was prepared from 2,306 plots of forest inventories, from different projects, which were systematized, refined, standardized, and analyzed to obtain the value of biomass for each individual greater than 10 cm DBH (Trees greater than 10 cm DBH[29] are included, because for Guatemala it is the definition of a tree). General allometric equations were applied, differentiating between broadleaf forests in Petén, coniferous forests, broadleaf forests and mangrove forests. In the latter, three species-specific equations were used. The factor 0.47 was used to convert biomass to carbon and the result per hectare was standardized by dividing the result by the plot size.

---

[27] For Guatemala, the following definition for a tree is used:
Woody plant with a defined stem and crown with secondary growth that, when mature, reaches a minimum height of 5 meters and a minimum diameter of 10 cm. Bamboos and palms are excluded.

[29] For Guatemala, the following definition for a tree is used:
Woody plant with a defined stem and crown with secondary growth that, when mature, reaches a minimum height of 5 meters and a minimum diameter of 10 cm. Bamboos and palms are excluded.

The second pool, which is related to the previous one, includes below-ground biomass (roots). To estimate below-ground biomass, an above-ground biomass ratio equation was used for all plots (Mokany, Raison & Prokushkin 2006), except for the Mangrove Forest plots, where an equation was used (Komiyama et al. 2008).

The following (see Table 5) shows the equations used to calculate the biomass above and below ground for the Petén, conifers, broadleaves and three mangrove species forests, which take into consideration the relationship in function of the proportion of aerial biomass for the below-ground biomass.

Table 37. Allometric equations used.

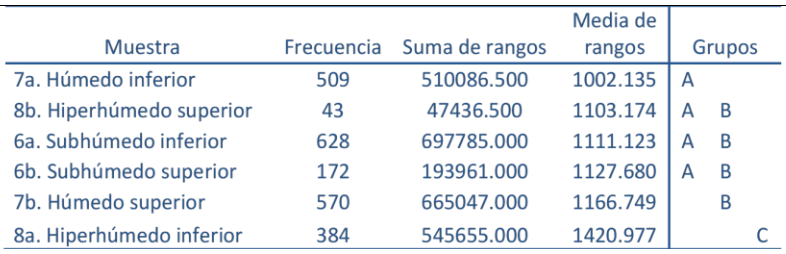
Species/Region	Equation	Source	r2	N	Dmax
Rhizophora mangle L.	0.178*DBH^2.47	Imbert and Rollet	0.98	17	Unknown
Laguncularia racemosa (L.)	0.1023*DBH^2.50	Fromard et al.	0.97	70	10
Avicennia germinans (L.) L.	0.14*DBH^2.4	Fromard et al.	0.97	25-45	42.4
Conocarpus erectus L.	0.1023*DBH^2.50	Fromard et al.			
Petén	10^ (-4.09992+(2.57782*LOG10(DBH))) *1000	Arreaga 2002	95	139	130
Broadleaf	0.13647 * DBH^2.38351	UVG 2015	0.939	100	79.9
Conifers	0.15991 * DBH^2.32764	UVG2015	0.966	80	82

With the biomass data for each individual, the conversion of tons of biomass to carbon is made, multiplying by the fraction of 0.47 and the value for one hectare is extrapolated, according to the size of each plot. The values are added for each of the plots, and results in a standardized value of tons of carbon per ha in each of them.

Each plot has geographic location data, and these were stratified bioclimatically, as an indirect measure of primary productivity, based on the ombrothermal indices generated for Guatemala, which were constructed with data obtained from the World Clim digital page, using the monthly precipitation and temperature averages. This climatic classification has been widely used in Guatemala as a basis for regional planning and for the integration of other variables of interest to forest services or biological conservation (CONAP, 2015).

The plots with their carbon content were located in 6 ombric horizons, and data distribution tests were carried out for each of them, finding that none presented normality in the data distributions. Therefore, to carry out the stratification according to the ombric horizons, a comparison test of k samples (Kruskal-Wallis) was carried out, where statistically differentiated groups were detected as shown below (See Table 6).

Table 38. Grouping categories according to climatic regime.



Muestra	Frecuencia	Suma de rangos	Media de rangos	Grupos		
7a. Húmedo inferior	509	510086.500	1002.135	A		
8b. Hiperhúmedo superior	43	47436.500	1103.174	A	B	
6a. Subhúmedo inferior	628	697785.000	1111.123	A	B	
6b. Subhúmedo superior	172	193961.000	1127.680	A	B	
7b. Húmedo superior	570	665047.000	1166.749		B	
8a. Hiperhúmedo inferior	384	545655.000	1420.977			C

As shown below, from the statistical grouping, four strata were determined at the national level according to the amount of carbon and the zones of ombric horizons (See Table 7). The groups that are observed in table 39, indicate those ombric indices that are statistically related to each other. That is why the result is four groups.

Table 39. Groups in which climatic regimes are classified.

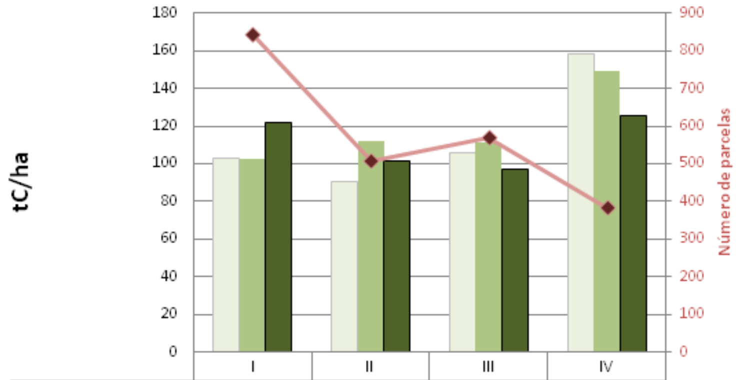
Sample	Groups			Final Group
6a. Subhumid – Low	A	B		I
6b. Subhumid – High	A	B		I
7a. Humid – Low	A			II
7b. Humid – High		B		III
8a. Hyper Humid - Low			C	IV
8b. Hyper Humid - High	A	B		I

With these data, the values were assigned to those areas whose ombric horizon did not have enough plots to be represented (e.g. Dry type), leaving the final stratification as detailed in Table 40, with which the national coverage is achieved.

Table 40. Strata assigned to horizons with insufficient values.

Stratum	**Ombric Type**	**Ombric Horizon**
I	4. Semi-Arid	4b. Semi-Arid – High
	5. Dry	5a. Dry – Low
	5. Dry	5b. Dry – High
	6. Sub-Humid	6a. Sub-Humid Low
	6. Sub-Humid	6b. Sub-Humid High
II	7. Humid	7a. Humid – Low
III	7. Humid	7b. Humid - High
IV	8. Hyper-Humid	8a. Hyper-Humid - Low
I	8. Hyper-Humid	8b. Hyper-Humid - High
	9. Ulta Hyper-Humid	9. Ulta Hyper-Humid

In order to have more consistent data in the estimation of tons of carbon per hectare and per stratum, descriptive statistics were made for each group and the resulting carbon content ranges were compared. Due to the great variability of the data according to the size of the plots and sampling designs, calculations of carbon density were made with the median and the weighted mean was also calculated for the four strata according to the proposal of Thomas and Rennie, 1987, who define that variance is a good estimator of the mean. Due to the variability of sampling designs for different purposes, data distribution (non-normal) and plot sizes, the Monte Carlo method was used to estimate carbon in the cartographic model (carbon map) because it weights directly the size of the plot and identifies the probability density function (PDF) of the data by plot size and by stratum through goodness-of-fit tests (Gómez Xutuc, 2017). Once the PDFs have been identified, it performs simulations of the carbon content per hectare, obtaining a better estimator from their Probability Density Functions (PDFs) (Figure 6). Thus, 10,000 simulations were run, truncating distributions according to the minimum and maximum of each data (tC/ha) by plot size and by stratum, respectively. The median was used for the analysis, since these are data that do not present a normal distribution.



	I	II	III	IV
Mediana	102.9	90.3	105.7	158.5
Mediaponderada	102.6	112.1	111.5	149.5
Monte Carlo	122.1	101.7	97.1	125.2
Parcelas	843	509	570	384

Figure6. Estimated values for the carbon map.

Value applied:

The final values of forest biomass above and below ground were as follows.

Table 41. Carbon values obtained for each stratum.

Strata	Median	Typical Deviation
I	122.06	0.187
II	101.73	0.553
III	97.11	0.459
IV	125.19	0.602

QA/QC procedures applied:

A bounded equation was made based on maximum and minimum carbon values. Poorly located plots that did not have a correct georeferencing location were purged located plots that did not have a correct georeferencing location were purged.

Additional analysis was done to check the accuracy of the map against the plots of the project inventories. Since the country also submitted a reference level to the United Nations Convention on Climate Change, we proceeded to review whether the correspondence of the map's carbon layers was in line with reality. Therefore, INAB proceeded to perform an analysis to evaluate the quality of the carbon layers map, which can be found in the folder in this link:

https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

<table>
<tr><td></td><td></td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>
Table 42. Uncertainty of the carbon strata after applying the Monte Carlo method.
<table>
<tr><th>Strata</th><th>Median</th><th>Uncertainty (%)</th></tr>
<tr><td>I</td><td>145.34</td><td>22.44</td></tr>
<tr><td>II</td><td>101.57</td><td>97.88</td></tr>
<tr><td>III</td><td>109.93</td><td>77.29</td></tr>
<tr><td>IV</td><td>153.70</td><td>60.80</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>
The values found in Table 42 are the result of the modeling for the carbon strata for the calculation of the uncertainty of the emission reduction.
</td></tr>
<tr><td>Any comment:</td><td>
Methodological report:
https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

Database to build the carbon strata of Guatemala:
https://docs.google.com/spreadsheets/d/1K7NZf9F5-ez1iYOvNYZmDcmrnmwYEa8o/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

Shapefile:
https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link
</td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>Non forest carbon content (Nofor)</td></tr>
<tr><td>Description:</td><td>Non-forest carbon content after conversion of forest land to non-forest land
Used in the equations: 8,18</td></tr>
<tr><td>Data unit:</td><td>Tons of carbon/ha</td></tr>
<tr><td>Source of data and description of measurement /calculation methods and procedures applied:</td><td>
In order to have an estimation of the emissions that is closer to reality and to assign a biomass existence value after deforestation, depending on the type of activity that is carried out, in addition to the data obtained for the country for agroforestry systems, the general default values were used for land converted to cropland during the year following conversion, from the 2006 IPCC Guidelines for Wet Tropical Annual and Perennial Crops and their associated error range found in IPCC Table 5.9 (2006). The values for these other non-forest use categories were used as described below (See Table 11):
Table 43. Carbon in biomass after conversion due to deforestation.
<table>
<tr><th>Other land uses</th><th>Ton Carbon/ha</th><th>Range of error and/or uncertainty</th><th>Source</th></tr>
</table>
</td></tr>
</table>

Croplands (all classes not specified) and grasslands	4.7	±75%	IPCC 2019 (Volume 4,Table 5.9, chapter 5 Croplands, annual croplands)
Croplands-Coffee (intensive)	2.65	±75%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in
Grasslands	6.73	±75%	IPCC 2006 (Table 6.4, chapter 6 Grasslands)
Croplands-African Palm	2.4	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Croplands-Rubber	3	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Agroforestry systems (shaded coffee)	20.1	1.34%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in Guatemala. PROMECAFE
Settlements	0.00	N/A	IPCC 2006
Wetlands	0.00	N/A	IPCC 2006
Other lands	0.00	N/A	IPCC 2006

Note: Since there are national values, it is suggested to leave this table to have all the non-forest carbon content values so that it is easier to replicate the Reference Levels and the Monitoring Period results in the process of rebuilding the estimation of reductions.

Value applied:

Other land uses	Ton Carbon/ha	Range of error and/or uncertainty	Source
Croplands (all classes not specified) and grasslands	4.7	±75%	IPCC 2019 (Table 5.9, chapter 5 Croplands, annual croplands)

Croplands-Coffee (intensive)	2.65	±75%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in
Grasslands	6.73	±75%	IPCC 2006 (Table 6.4, chapter 6 Grasslands)
Croplands-African Palm	2.4	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Croplands-Rubber	3	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Agroforestry systems (shaded coffee)	20.1	1.34%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in
Settlements	0.00	N/A	IPCC 2006
Wetlands	0.00	N/A	IPCC 2006
Other lands	0.00	N/A	IPCC 2006

Note: Since there are national values, it is suggested to leave this table to have all the non-forest carbon content values so that it is easier to replicate the Reference Levels and the Monitoring Period results in the process of rebuilding the estimation of reductions.

QA/QC procedures applied:

Does not apply because they are default values taken from the IPCC Guidelines.

Uncertainty associated with this parameter:

Table 44. Uncertainty of carbon content in non-forest land

Classification	Agriculture	Coffee	Palm	Rubber	Agroforestry	Grasslands
Mean	4.7	2.6	2.4	3.0	20.3	6.7
Average	4.7	2.7	2.4	3.0	20.2	6.8
Deviation	3.1	0.3	0.2	0.0	361.6	55.8
CI – lower limit	1.22	1.64	1.44	2.63	-16.72	-7.78
CI – upper limit	8.15	3.70	3.35	3.38	57.12	21.51
%	73.43	38.93	39.83	12.58	181.82	218.33

Any comment:	To access the documents and calculations related to this activity, consult the following link: Chapter Croplands for Croplands: https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch05_Cropland.pdf Chapter Croplands for African Palm and Rubber: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf Chapter Grasslands https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf Data for intensive coffee and Agroforestry systems (shaded coffee): https://drive.google.com/file/d/1kXI5Pxr_iUJOffJJTfVBTjF2iWihs3tq/view?usp=drive_link https://docs.google.com/presentation/d/1JjSan9z5CYySzZuhCwRWxW9c1tR2nyww/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

Parameter:	Emissions from degradation (Cfor-Cdeg)
Description:	Corresponds to the degradation that occurs between 30% to 70% of the forest carbon content. Used in the equations: 9 and 19
Data unit:	Ton of carbon Tons of carbon/ha
Source of data and description of measurement/calculation methods and procedures applied:	The degradation that occurs in areas that remain as forests was also included in the FREL. This phenomenon occurs due to a partial removal of trees that results in a decrease in forest cover in the monitoring period. This process implies loss of tree elements in aerial and underground carbon reservoirs, through the selective and intensive extraction of forest resources (trees for firewood, local use or commercial transformation) or the mortality of trees due to the effect of a forest fire. Fire degradation processes have been estimated to contribute up to 9% of national emissions (GIMBUT 2018b). Degradation processes have also been identified with greater pressure from the unsustainable extraction of firewood for residential, commercial and industrial use, since it is estimated that 70% of households in Guatemala use it to cover their needs. Additionally, there are illegal extraction activities linked to the weakness of governance and it is estimated that 95% of the flow of forest products are of illicit origin with uncontrolled and selective extraction (GCI, 2018b). Forest carbon content after the forest degradation process

To establish the content of forest degradation, it was assumed that this occurs when a Collect Earth plot loses between 30% to 70% of the elements that are categorized as trees and 50% of the initial forest content is lost, within the study period without reaching the deforestation process.

To establish the thresholds for forest degradation and degradation recovery, it was agreed with GIMBUT and the World Bank specialists to assume that the degradation and recovery process occurred between 30% and 70%, assuming that 50% is lost.

Value applied:

Above-ground carbon

Table 45. Criteria used to classify degraded plots.

Type of forest	(tC/ha)
Forests I (>70%) to degraded (70-30%)	61
Forests II (>70%) to degraded (70-30%)	51
Forests III (>70%) to degraded (70-30%)	49
Forests IV (>70%) to degraded (70-30%)	63

For the criteria of using degradation thresholds, it was assumed that the plot in a degradation process loses 50% of the original forest carbon content. This assumption was validated with technicians from government institutions.

QA/QC procedures applied:

Does not apply because they are default values, taken from the forest carbon content and emission factors used for deforestation.

The assumption was made that since 50% of the forest carbon content that is lost is used, the information used as a basis is the carbon strata map, so no new information was generated.

Uncertainty associated with this parameter:

Table 46. Forest degradation uncertainties.

Classification	Stratum 1	Stratum II	Stratum III	Stratum IV
Median	51	43	52	80
Average	53	62	82	124
Deviation	563	6,310	12,418	19,260
CI – lower limit	54	86	78	84
CI – upper limit	62	314	402	366
%	58	200	240	225

Any comment:

To access the documents and calculations related to this activity, consult the following link:

Methodological report:

https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

	Database to build the carbon strata of Guatemala: https://docs.google.com/spreadsheets/d/1K7NZf9F5-ez1iYOvNYZmDcmrnmwYEa8o/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true Shapefile: https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link

<table>
<tr><td>Parameter:</td><td>Removals from forest degradation recovery (Cdeg-Cfor)</td></tr>
<tr><td>Description:</td><td>Corresponds to the forest carbon content that is recovered from degradation. This recovery occurs when 30% to 70% of the plot recovers the conditions.
Used in the equations: 10 and 20</td></tr>
<tr><td>Data unit:</td><td>Ton of carbon/ha</td></tr>
<tr><td>Source of data or description of the method for developing the data, including the spatial level of the data (local, regional, national or international):</td><td>The recovery of degraded areas occurs in areas that remain as forests; it was also included in the FREL. This phenomenon occurs due to a partial recovery of trees that results in an increase in forest cover in the monitoring period.

This process involves the recovery of tree elements in aerial and underground carbon reservoirs, through recovery, through selective and intensive anthropogenic activities of forest resources (restoration of forest areas).

To establish the forest carbon content that is recovered from the forest degradation process, the plots that recovered 30% to 70% of the elements that were categorized as trees were used and recover 50% of the forest carbon content. This occurs within the study period.

To establish the thresholds for forest degradation and degradation recovery, it was agreed with GIMBUT and the World Bank specialists to assume that the degradation and recovery process occurred between 30% and 70%, assuming that 50% is lost.

For the criteria of using recovered from the forest degradation thresholds, it was assumed that the plot in a degradation process loses 50% of the original forest carbon content. This assumption was validated with technicians from government institutions.</td></tr>
<tr><td>Value applied:</td><td>Above-ground carbon
Table 47. Criteria used to classify degraded plots.
<table>
<tr><th>Classification</th><th>(tC/ha)</th></tr>
<tr><td>Forest I restored</td><td>61</td></tr>
<tr><td>Forest II restored</td><td>51</td></tr>
<tr><td>Forest III restored</td><td>49</td></tr>
</table></td></tr>
</table>

<table>
<tr><td></td><td><table><tr><td>Forest IV restored</td><td>63</td></tr></table></td></tr>
<tr><td>**QA/QC procedures applied:**</td><td>Not applicable at the moment, due to the approach used to calculate the data.

The assumption was made that since 50% of the forest carbon content that is lost is used, the information used as a basis is the carbon strata map, so no new information was generated.</td></tr>
<tr><td>**Uncertainty associated with this parameter:**</td><td>Table 48. Uncertainty of carbon contents in restored lands.
<table>
<tr><th>Classification</th><th>Stratum 1</th><th>Stratum II</th><th>Stratum III</th><th>Stratum IV</th></tr>
<tr><td>Median</td><td>51</td><td>43</td><td>52</td><td>80</td></tr>
<tr><td>Average</td><td>53</td><td>62</td><td>82</td><td>124</td></tr>
<tr><td>Deviation</td><td>563</td><td>6,310</td><td>12,418</td><td>19,260</td></tr>
<tr><td>CI – lower limit</td><td>54</td><td>86</td><td>78</td><td>84</td></tr>
<tr><td>CI – upper limit</td><td>62</td><td>314</td><td>402</td><td>366</td></tr>
<tr><td>%</td><td>58</td><td>200</td><td>240</td><td>225</td></tr>
</table>
These are the values corresponding to the forest carbon content that arise from the Montercarlo Model.</td></tr>
<tr><td>**Any comment:**</td><td>To access the documents and calculations related to this activity, consult the following link:

Methodological report:
https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

Database to build the carbon strata of Guatemala:
https://docs.google.com/spreadsheets/d/1K7NZf9F5-ez1iYOvNYZmDcmrnmwYEa8o/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

Shapefile:
https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link</td></tr>
</table>

Parameter:	Removals due to increased carbon through forest plantations (AAI)
Description:	Carbon content that is recovered through the implementation of coniferous and broadleaf plantations.
Data unit:	Tons of carbon per hectare

Source of data or description of the method for developing the data, including the spatial level of the data (local, regional, national or international) :

To estimate this data, data from growth curves taken from 28 species of trees in forest plantations in Guatemala were used (INAB 2014). These results come from the assessment of sampling units called "Permanent Forest Measurement Plots (*PPMF, for its acronym in Spanish*)," which are distributed in 90 municipalities within the 22 departments of Guatemala, and their location is due to the behavior of the geographical distribution of the forest plantations established mainly with the PINFOR Forestry Incentive Program of the National Forest Institute (INAB) since 1998.

The Average Annual Growth Increments (AAGIs) were obtained by dividing the forest species by type of forest (broadleaf and coniferous), identifying which type of forest each forest species belongs to. Robust estimates of AAGIs for broadleaf and coniferous forests were generated from the Permanent Forest Measurement Plots (PPMF) database. The best fitted functions to probability density data (PDD) are normal for broadleaf forests and gamma for coniferous forests. Monte Carlo simulations were performed on these distributions to make more precise estimates and the final values of the AAGIs were calculated. Table 17 show the AAGIs for each plantation type in Guatemala.

Table 49. AAGI for each type of forest plantation.

Capture factor	Median (m^3 ha^{-1} year^{-1})
AAGI in broadleaf forest	3.43
AAGI in coniferous forest	7.88

The document called "Wood Densities of Tropical Tree Species" was used for the selection of wood densities. It contains a scientific study of tree densities in tropical forests in America. Also, as support and by way of comparison, the document "Conifers of Guatemala" was used, which contains densities of tree species belonging to the coniferous forest group (DATAFORG 2000, Reyes et al. 1992).

With the ordered basic density data, an average wood density was obtained for the broadleaf and coniferous forest. To obtain the average wood density for each type of forest, the species belonging to each tree community were identified and the arithmetic mean was calculated (See Table 18).

Table 50. Wood density according to the different types of plantations.

Type of forest	Density g/cm^3
Broadleaf Forests	0.62
Coniferous Forests	0.61

Biomass Expansion Factors (BEFs) are added to these values, which correspond to the ratio between aerial biomass and below-ground biomass (AB:BB) and the carbon fraction (CF), with IPCC default values, as shown below (See Table 19).

Table 51. Expansion factors, below-ground aerial biomass ratio and carbon fraction for forest plantations.

	BEF	AB:BB	CF
Broadleaf Forest	1.50	0.2	0.47
Coniferous Forest	1.20	0.2	0.47

Finally, the carbon per hectare per year data is converted to a COe$_{q2}$ removal or absorption factor by multiplying it by the IPCC default factor of 44/12. Once all the calculations have been made, the values for plantations in broadleaf forests and plantations in coniferous forests are obtained (See **Error! Reference source not found.**).

Value applied:

Above-ground carbon.

Table 52. Values for plantations in broadleaf forests and plantations in coniferous forests

Classification	RF (tC/ha)	RF (t CO_{2eq}/ha)
Broadleaf Forest	1.80	6.60
Coniferous Forest	3.25	11.93

QA/QC procedures applied:

Not applicable at the moment, due to the approach used to calculate the data.

The following criteria were used to filter the information on forest plantations:

- Records of plantation initiation between the years 2001 to 2010.
- Agroforestry systems and reforestation modality (on the recommendation of Winrock International's advisors, the quantification of existing areas of
- Agroforestry Systems within the PINPEP forestry incentive, as these are incentivized areas that are sequestering carbon).
- The records should contain location polygon not points.
- Plantation area in hectares for each record.

Based on the criteria described above, the data was cleaned and selected using software for geographic data management. For more information, in the any comments section you can find the protocol to calculate the IMA.

Uncertainty associated with this parameter:

Table 53. Uncertainty of carbon contents in lands that are recovered through forest plantations.

Classification	Broadleaf Forest	Coniferous Forest
Median	37,823	85,258
Average	82,184	101,185
Deviation	22,808,404,571	4,778,004,942
CI – lower limit	3,088	14,698
CI – upper limit	414,596	271,351
%	536	148

Any comment:	To consult the data you can do it through this link: Database: https://drive.google.com/drive/folders/1QFuxCTGlG_qJXF4JLCOvxUWVugyRr8HX?usp=drive_link Document: https://drive.google.com/file/d/1tS8nzi-YIzMB-JWCCuH94vk2p_WwPEGc/view?usp=drive_link

8.4 Estimated Reference Level

Accreditation period year *t*	**Annual average of historical emissions derived from deforestation during the Reference Period (tCO_{2eq}/year)**	**If applicable, annual average of historic emissions from forest degradation during the Reference Period (tCO_{2eq}/year)**	**If applicable, annual average of historical removals by sinks during the Reference Period (tCO_{2eq}/year)**	**Adjustment, if applicable (tCO_{2eq}/year)**	**Reference level (tCO_{2eq}/year)**
2020	10,412,105.49	3,756,434.67	-2,354,303.98		11,814,237.18
2021	10,412,105.49	3,756,434.67	-2,354,303.98		11,814,237.18
2022	10,412,105.49	3,756,434.67	-2,354,303.98		11,814,237.18
2023	10,412,105.49	3,756,434.67	-2,354,303.98		11,814,237.18
2024	10,412,105.49	3,756,434.67	-2,354,303.98		11,814,237.18

Calculation of the average annual historical emissions over the Reference Period

The reference level of the Guatemalan Emission Reduction Program in deforestation, degradation and carbon increases was calculated using the baseline presented in the ERPD, which covers 10 years, from 2006 to 2016. Within the ERPA agreement, it is estimated that each year there is a net emission of around 11,839,217.99 tons of CO_{2eq}/year.

The sampling approach was used, with which the activity data were created, and the information generated through the carbon strata of Guatemala was used to obtain information on above and below-ground biomass. A literature review was also done to obtain data on carbon content factors for non-forest uses.

8.5 Upward or downward adjustments to the average annual historical emissions over the Reference Period (if applicable)

Explanation and justification of proposed upward or downward adjustment to the average annual historical emissions over the Reference Period

No adjustments have been made to the reference level. reference period.

Quantification of the proposed upward or downward adjustment to the average annual historical emissions over the Reference Period

Not applicable.

8.6 Relation between the Reference Level, the development of a FREL/FRL for the UNFCCC and the country's existing or emerging greenhouse gas inventory

Guatemala has a reference level in the UNFCCC that has been recently presented in the month of February 2022 and which maintains coherence and consistency with the FREL that is subject to an ERPA before the FCPF, since the same activity data and emission/absorption factors were used. The difference between the two reference levels is that the one presented to the UNFCCC is at the national level, so it includes the points of the areas excluded from the ERP under the ERPA, which are the Candelaria triangle and the municipalities of Izabal. The fact that both reference levels have been calculated in the same way allows reinforcing and implementing the country's REDD+ Strategy.

It is also important to mention that the activity data and emission and absorption factors used in these reference levels are the same as those used for the LULUCF sector in the GHGIs presented in the Third National Communication on Climate Change. This allows for the coherence and consistency of national data and processes to be maintained. The difference between the reference levels and the GHGIs is that the GHGIs include additional activities that are not considered in the REDD+ framework.

9 APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

9.1 Measurement, monitoring and reporting approach for estimating emissions occurring under the ER Program within the Accounting Area

>> The MRV system of the forest sector has been built according to the capacities in the country, and based on existing platforms, studies, data and processes, taking into account a diversity of governmental and non-governmental institutions, including academia, research centers and civil society organizations. In addition, it is based on the current legal frameworks: Forestry Law (Decree 101-96), Law of Protected Areas (Decree 4-89), and the Framework Law to Regulate the Reduction of Vulnerability, the Mandatory Adaptation to the Effects of Climate Change and Greenhouse Gas Mitigation (Decree 7-2013). These laws mandate the different government institutions to collect and process information according to their scope of action.

The ERPA MRV system is part of this forest sector MRV system. For the implementation of this specific system, it is considered that it will be coordinated by INAB, as the Executing Unit of the Program, with the support of the Working Group for the Preparation of the First ER Report of Guatemala, and integrated by technical staff from the GIS units and the climate change units/departments/ directorates of the institutions of the GCI, as well as by representatives of REDD+ projects. The preparation of this report was complemented with the support of specialists from U*niversidad del Valle de Guatemala* for the carbon accounting section.

All the information generated by the different institutions was integrated and systematized by INAB within the framework of the ERPA of the ER Program under the FCPF. In this sense, INAB has been an integrating unit and generator of the reports before the FCPF. It is in close coordination with MARN, as focal point before the UNFCCC, to ensure consistency between the information generated in the framework of the ERP and what is reported for other initiatives and commitments under the United Nations Framework Convention on Climate Change (UNFCCC), including GHG inventories for the LULUCF sector.

It is important to point out that each government institution participating in the development of data for the preparation of the First Emissions Reduction Monitoring Report provides different inputs according to their competencies and existing and current inputs.

Table 54. Participating institutions in the elaboration of the First Emissions Reduction Monitoring Report and the inputs provided.

Institution	Inputs

INAB / Emission Reduction Program Executing Entity (Coordinatior, Technical coordinatior, departments of GIS and Climate change)	Coordinate ER monitoring report integration
	Forest Cover Maps (in collaboration with CONAP).
	National Forest Inventory.
	List with information and maps/polygons on the areas subject to incentives by PINPEP, PINFOR, and PROBOSQUE.
	Data, maps and/or polygons linked to the use of firewood and legal and illegal selective logging.
	Estimation of average annual increments (AAI), and removals due to increased carbon stocks at the national level, through forest management and reforestation (management of natural forests, plantations, AFSs, forestry incentives) and natural regeneration.
	Emission factors for degradation and Removal factors for increases in carbon stocks.
	Participate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.
CONAP / Climate Change Unit and the Geospatial Analysis Directorate, Center for Evaluation and Monitoring (CEMEC) located in Petén.	Forest Cover Maps (in collaboration with INAB) Forest fires data Participate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.?
MAGA / Geographic, Strategic Information and Risk Management and Climate Change Unit.	Develop anciliary datta such as vegetation cover and land use maps, for a potential estimate of carbon in the land uses. Suppor monitoring report integration.
MARN / Science and Metrics Department and the Mitigation Department of the Climate Change Unit, as well as in the Environmental Information and Climate Change Unit.	Reference Level of National Emissions for the Forest Sector and other land uses.
	Staff to standardize and ensure that there is consistency in the data presented in the ERP before the FCPF, the Greenhouse Gas Inventories (GHGIs), the reference level presented to the UNFCCC and the Registry of Projects for the Removal or Reduction of Greenhouse Gas (GHG) Emissions. Coordinate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.
REDD+ Projects Guatecarbon, Forests for Life, Networks for Local Development (REDDES)	Technical staff
	Data from REDD+ projects, polygon activities, etc.
	Community monitoring data.
	Relevant scientific studies and research.
	Complaints linked to drivers of deforestation and forest degradation.
Universidad del Valle de Guatemala	Support on carbon accounting, data procesing… Support on visual interpretation of sample units of the national grid for generating LULUC Activity Data. Support on ER monitoring reor development.

	Support on uncertainty and sensitivity analisys.

Regarding the monitoring report, the Working Group for the Preparation of the First ER Report of Guatemala processes the information and results of the estimates resulting from the analysis of the activity data and emission factors during the period of the ER Program and, then, subsequently transfers them to INAB so that it prepares the report to the FCPF (Figure 7). In turn, INAB transfers them to MARN for the report to the UNFCCC.

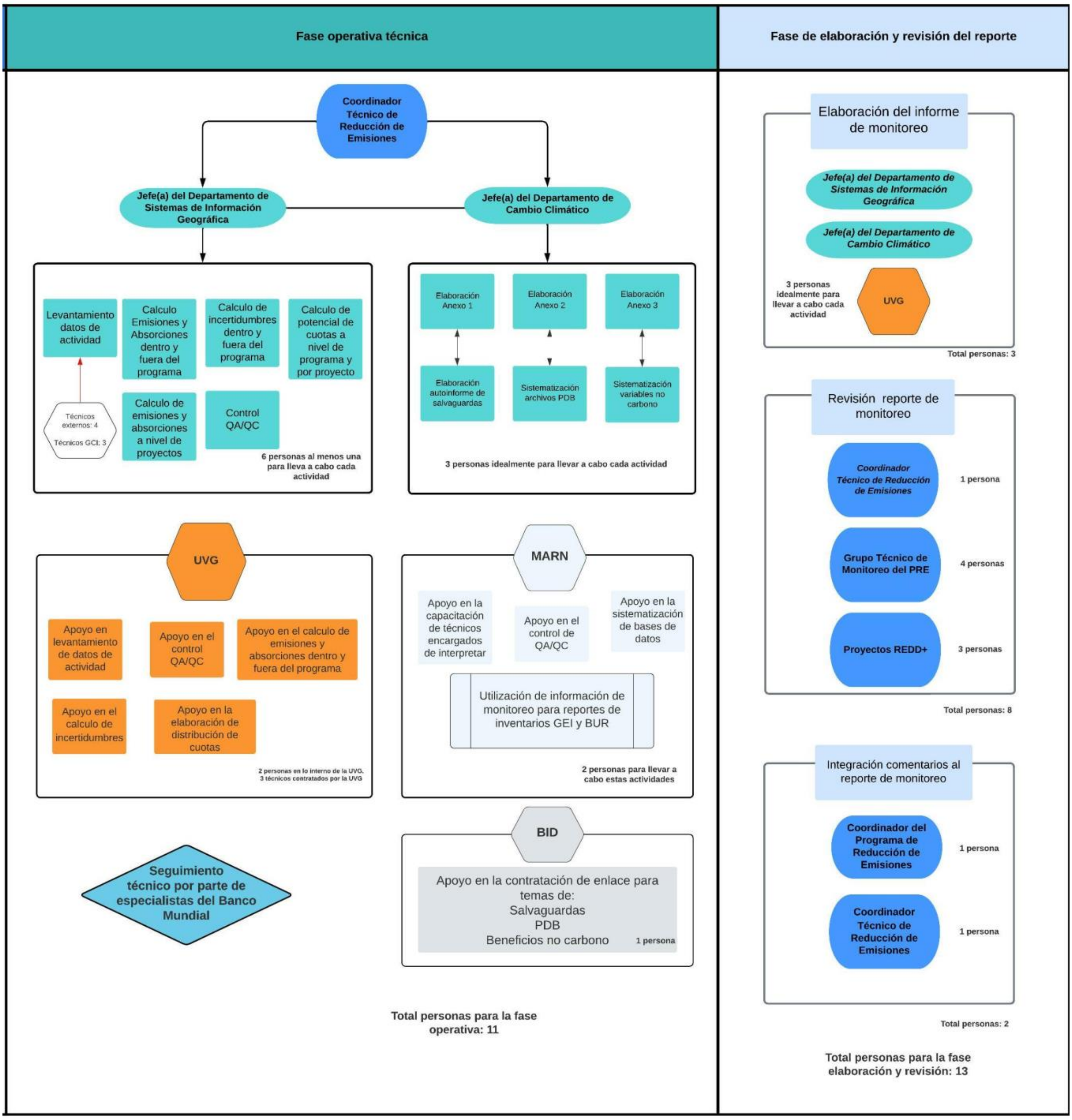


Figure 7. Process for the elaboration of the monitoring, validation and reporting report

Line diagrams

The following diagram (Figure 4) shows the different components of the MRV System of the emission reduction program under the FCPF, where the main activities related to the generation of activity data, the estimation of emission/removal factors and the calculation of emissions and removals to obtain the emission reductions for the year of interest are presented. This line diagram is complemented by Figure 3, which details those responsible for the preparation of carbon accounting, safeguards, benefit sharing plan and non-carbon variables. The line diagram shows the step by step (seven steps in total) of each of the steps that are needed to have as a final result the emission reductions for the monitoring period.

For the process of calculating emissions reductions, the line diagram is intended to show the different processes from the generation of activity data, the allocation of carbon content, obtaining the emission and removal factors to obtain the emissions and removals of the reference level and the first monitoring. These processes are in charge of the head of the Geographic Information Systems unit of INAB with technical support from UVG.

Each step of the line diagram is described below:

- Step 1 Simple Base Area Estimation:

Consists of the use of the collect earth tool which allows us to use the high resolution images available in the Google Earth catalog. The tool also has external support to consult Planet, Sentinel and Landsat images, as well as to consult vegetation indexes. The document can be accessed:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

- Step 2 Visual interpretation of the CEP form:

In this step the visual interpretation of the 11,369 plots that are randomly distributed in Guatemala is performed. The collect earth form allows to establish the coverage and use for the current year, as well as to establish the coverage of the previous year. It also assigns whether the plot is a permanence or change in use, in addition to recording the date of the images used. The database is then exported and transformed from a comma-separated format to an Excel file. The form can be accessed through this link:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

CEO Project: https://drive.google.com/drive/folders/1IhxjFz5gPGKg-qCbXXBwU9cDOSnQ0E5m?usp=drive_link

- Intermediate step Prepare emission factors:

In this step we proceed to assign to each of the plots in Guatemala, the forest content stratum to the plots this with the objective of identifying the plots that had a change of use and to know the carbon content prior to deforestation or degradation.

The carbon layer map can be accessed through this link:
https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link
(Open with ArcGis)

The methodological protocol document can be accessed through this link:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

Step 3 Area estimation:
In this stage we proceed to calculate the hectares for each of the REDD+ activities that Guatemala reports, which are deforestation, degradation, carbon increments through the recovery of degradation and forest plantations. To estimate the area, the file "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" is used, and the data is found in column D for the reference level as for the first monitoring.

The document can be accessed through this link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

- Step 4 Allocation of emission factors:

In this step the process that is done is to identify the transitions of all conversions that pertain to deforestation to identify which land use it is and thereby allocate the carbon contents pre and post deforestation.

In the case of degradation and recovery from degradation, the carbon stratum is identified in order to deduct 50% of the carbon initially held. To identify the emission factors from both forest and non-forest carbon content, use the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" and consult the column P, both for the reference level and the first monitoring.

The excel file can be consulted at the following link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

- Step 5: Calculation of CO2/year per activity

In this step the process is to make the sum of the transitions associated with deforestation, degradation, increases in carbon by recovery of degradation and forest plantations. After the summation, the division is made in the corresponding years between the monitoring period or the reference level period. To identify the emissions from the identified activities, the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" can be used and the column AB can be consulted, both for the reference level and the first monitoring.

The excel file can be consulted at the following link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

- Step 6 Calculation of emissions/removals:

The next step is to obtain the net emissions of the reference level period as the first monitoring period. To perform this calculation, the emissions from deforestation and degradation are added to the sum of the removals from carbon enhancements from restoration of degradation and forest plantations. This operation gives the net emissions, which can be positive, indicating emissions, and negative, indicating removals. To identify the emissions from the identified REDD+ activities, the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" can be used and consult the Summary tab, both for the reference level (Column C) and the first monitoring (Column D).

The excel file can be consulted at the following link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

- Step 7 Emission reduction calculation:

This step is performed using the net emissions of the reference level period and subtracts them from the net emissions of the monitoring period to obtain the emission reductions. To identify the reductions from the identified REDD+ activities, use the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" and consult the Summary tab, and check column E.

The excel file can be consulted at the following link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

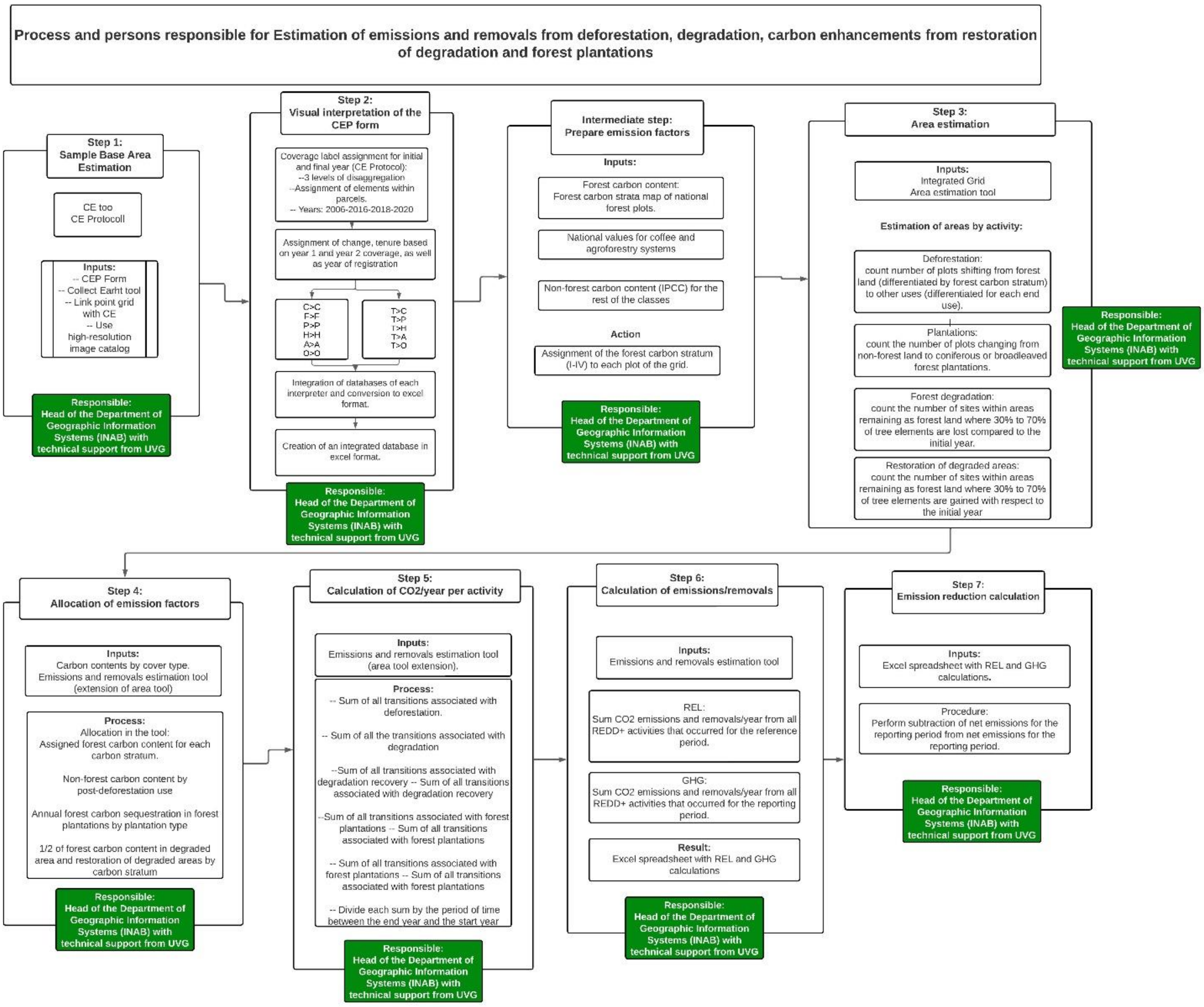


Figure 8. Components for calculating the program's emission reductions.

Calculation steps

The RL estimation may be found here, yet a description of the equations is provided below. RL was defined as the net annual average historical emissions. Annual emissions or absorptions were estimated for all land transitions by REDD+ activity, and then adding the results for all selected REDD+ activities for each year.

The REDD+ activities that are included in the reference level for Guatemala are:

- Emissions from deforestation and forest degradation.
- Absorptions from increases in forest stock that may be due to recovery of forest degradation and forest plantations.

Equation:

$$\mathbf{RL=(Def+deg)-(Incr) = (E_{DEF}+ E_{DEG}) - (R_{rec}+ R_{pla}) = ((ADef * FE) + (ADdeg * FE) - (Rrec * FA) - (Rpla * FA))}$$

Where:

RL = Reference Level
$\mathbf{E_{DEF}}$ = Emissions from Deforestation
$\mathbf{E_{DEG}}$ = Emissions from degradation

$\mathbf{R_{rec}}$ = Removals from forest degradation recovery

$\mathbf{R_{pla}}$ = Removals due to increased carbon through forest plantations

AD = Activity data for conversion of forest lands to other lands (Deforestation), permanent forest lands with forest cover loss (Degradation),and degraded permanent forest lands that increase their forest cover and establishment of forest plantations (Increases).

FE = Emission factors for deforestation and degradation.

FA = absorption factors for carbon increases in forest biomass.

To determine the emissions of the reference level, the first step is to calculate the information from the activity data and then make the estimate in tons of CO_2 equivalent.

Below you will find the links to the files to estimate the activity data, as well as the emissions and removals of the reference level.

- File containing the estimates of emissions and removals for each of the REDD+ activities:
- File that contains the information of the point grid with its categories of land use:

3.3. Reference level activity data

3.3.1. Activity Data of deforestation

To determine the activity data, a random mesh was used consisting of 11,369 plots for the entire country and 10,414 plots for the program area. Each plot has a total of 25 elements and the use is determined by the coverage that predominates.

Equation 3:

$$AD_{def}=\left(\frac{N_{def}}{N_{Total}}\right)*T$$

Where:

AD_{def} = Data derived from deforestation

N_{def} = Number of plots that were interpreted as deforestation in the period studied

N_{Total} = Total number of parcels found in the program area

T = Surface area of the program expressed in hectares

3.3.2. Activity data for degradation

Equation 4:

$$AD_{deg}=\left(\frac{N_{deg}}{N_{total}}\right)*T$$

Where:

AD_{deg} = Activity data derived from forest degradation

N_{deg} = Number of plots of forest remaining forest where forest cover loss is between 30-70%.

N_{total} = Total number of parcels found in the program area

T = Surface area of the program expressed in hectares

3.3.3. Forest degradation recovery activity data

Equation 5:

$$AD_{rec} = \left(\frac{N_{rec}}{N_{total}}\right) * T$$

Where:

AD_{rec} = Activity data derived from recovery from forest degradation
ND_{rec} = Number of plots of forest remaining forest where forest cover gain is between 30-70%
N_{total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

3.3.4. Increases for forest plantations

Equation 6:

$$AD_{pla} = \left(\frac{N_{pla}}{N_{total}}\right) * T$$

Where:

AD_{pla} = Activity data for reforestation through forest plantations
N_{pla} = Number of plots that goes from non forest lands to forest plantations

N_{total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

3.3.5. Activity data for forest land maintained as forest land

Equation 7:

$$AD_f = \left(\frac{N_f}{N_{total}}\right) * T$$

This formula is used to find out if the forest plots have undergone a degradation process or a degradation recovery process.

Where:

AD_f = Activity data for forest land maintained as forest land
N_f = Number of plots that are categorized as forest that remain as forest.
N_{total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

3.4. Reference level emission and removal data

3.4.1. Emissions from Deforestation

Equation 8:

$$\mathrm{Edef} = \sum_{\mathbf{j,i}} \left(\left(\mathrm{C}_{\mathrm{for}} - \mathrm{C}_{\mathrm{nofor}}\right) \mathrm{x} \, \frac{44}{12} \times \mathrm{A(j,i)} \right) / RP$$

Where:

Edef = Emissions caused by deforestation (tCO2 per year)

$\underline{A}_{(j,i)RP}$ = Area from activity data that has been converted from forest type j to non-forest type i during the Reference Period, in hectares per year. In this case, Guatemala, the forests have a division based on four carbon strata:

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

Ten types of non-forest land are considered:

- Cropland (C): What are annual crops, African palm, rubber and coffee. What are annual crops, African palm, rubber and coffee.
- Agroforestry systems such as shade-grown coffee was separated.
- Grassland (P);
- Wetland (A);
- Settlement (U); and
- Other lands (O).

$\underline{C_{for}}$ = Total forest carbon content of each strata j before conversion/transition, in tons of carbon per ha.

$\underline{C_{nofor}}$ = Total non forest carbon content of each non-forest land use i after conversion, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

The conversions identified for the reference level for Guatemala are the following:

Forest to croplands

37. Forest I to cropland lands
38. Forest II to cropland lands
39. Forest III to cropland lands
40. Forest IV to cropland lands
41. Forest I to cropland-coffee lands
42. Forest II to cropland-coffee lands
43. Forest III to cropland-coffee grounds
44. Forest IV to cropland-coffee lands
45. Forest I to cropland lands-African palm
46. Forest II to cropland lands-African palm
47. Forest III to cropland fields-African palm
48. Forest IV to cropland lands-African palm
49. Forest I to cropland lands-rubber
50. Forest II to cropland-rubber lands
51. Forest III to cropland-rubber grounds
52. Forest IV to cropland-rubber lands

Forest to agroforestry systems

53. Forest I to agroforestry systems

54. Forest II to agroforestry systems
55. Forest III to agroforestry systems
56. Forest IV to agroforestry systems

Forest to grasslands

57. Forest I to grasslands
58. Forest II to grasslands
59. Forest III to grasslands
60. Forest IV to grasslands

Forest to settlements

61. Forest I to settlements
62. Forest II to settlements
63. Forest III to settlements
64. Forest IV to settlements

Forest to other lands

65. Forest I to other lands
66. Forest II to other lands
67. Forest III to other lands
68. Forest IV to other lands

Forest to wetlands and bodies of water

69. Forest I to wetlands and bodies of water
70. Forest II to wetlands and bodies of water
71. Forest III to wetlands and water bodies
72. Forest IV to wetlands and water bodies

The following tables show the forest carbon content as well as the content of other non-forest land uses. The origin of each of the values is shown in more detail in Chapter 3 and the respective sections of the report (Annex 4 and 5).

Forest carbon content

Stratum	Forest carbon content – Cfor-- (Ton/ha)
Forest I	122.06
Forest II	101.73
Forest III	97.77
Forest IV	125.19

Non-forest carbon content

Non forest land Use	Non forest carbon content – Cnofor-- (Ton/ha)
Croplands (all classes not specified) and grasslands	4.7
Croplands-Coffee (intensive)	2.65
Grasslands	6.73
Croplands-African Palm	2.4
Croplands-Rubber	3
Agroforestry systems (shaded coffee)	20.1
Settlements	0
Wetlands	0
Other lands	0

3.4.2. Emissions from degradation

Equation 9:

$$Edeg = \sum_{\mathbf{j,i}} ((\mathrm{Cfor} - \ \mathrm{Cdeg}) \ \mathrm{x} \ \frac{44}{12} \times \ \mathrm{A(j,i)} \ \ )/RP$$

Where:

Edeg = Emissions caused by forest degradation in hectares per year

$\underline{A}_{(j,i)RP}$ = Activity data area that has undergone a degradation process within the forest cover during the reference period, in hectares per year. In the case of Guatemala, the analysis of forest degradation was made for the four strata that Guatemala has.

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

<u>Cfor</u> = Total forest carbon content of each forest type j before conversion/transition, in tons of carbon per ha.

Cdeg = Forest carbon content of each degradated forest type j, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

3.4.3. Removals from forest degradation recovery

Equation 10:

$$Edeg = \sum_{\mathbf{j,i}} \ ((\mathrm{Cdeg} \ \ - \mathrm{C_{for}}) \ \mathrm{x} \ \frac{44}{12} \times \ \mathrm{A(j,i)} \ \ )/RP$$

Where:

Rrec = Removals obtained from the recovery of forest degradation in hectares per year

$\underline{A}_{(j,i)RP}$ = Area that have had a recovery from degradation within the forest cover during the reference period, in hectares per year. In the case of Guatemala, the analysis of forest recovery degradation was made for the four strata that Guatemala has.

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

Cdeg = Forest carbon content of each degradated forest type j, in tons of carbon per ha.

Cfor = Total forest carbon content of each forest type j before conversion/transition, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

3.4.4. Removals due to increased carbon through forest plantations

Equation 11:

$$Rpla = \sum_{\mathrm{j,i}} ((AAI) \text{ x } \frac{44}{12} \times \mathrm{A(j,i)} \quad)/RP$$

Where:

Rpla = Removals obtained by the establishment of forest plantations in hectares per year

$\underline{A}_{(j,i)RP}$ = Area that has been identified as forest plantation. In the case of Guatemala, two types of plantations are managed:

- Broadleaf Plantation
- Conifer plantation

AAI = Average annual increase that was identified for each of the types of forest plantations, in this case:

- Broadleaf plantations
- Coniferous plantations

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

Parameters to be monitored

Parameter:	Deforestation
Description:	Forest land converted to non-forest uses The following equations were used to calculate this parameter: Activity data: Equation 13 Additionally, to convert the data to emissions we used equation 1*8*.
Data unit:	Hectares
Value monitored during this Monitoring / Reporting Period:	For deforestation, the land representation categories being used are those according to the IPCC.

Table 55. Deforestation within the monitoring period

Category	(Ha)
Forest I to cropland	958.89
Forest II to cropland	3,835.58
Forest III to cropland	958.89
Forest IV to cropland	0
Forest I to cropland-coffee	0
Forest II to cropland-coffee	0
Forest III to cropland-coffee	0
Forest IV to cropland-coffee	0
Forest I to cropland-African palm	0
Forest II to cropland-African palm	958.89
Forest III to cropland-African palm	0
Forest IV to cropland-African palm	0
Forest I to cropland-rubber	0
Forest II to cropland-rubber	0

Forest III to cropland-rubber	0
Forest IV to cropland-rubber	0
Forest I to agroforestry systems	958.89
Forest II to agroforestry systems	958.89
Forest III to agroforestry systems	958.89
Forest IV to agroforestry systems	0
Forest I to grasslands	14,383.42
Forest II to grasslands	8,630.05
Forest III to grasslands	6,712.26
Forest IV to grasslands	1,917.79
Forest I to settlements	0
Forest II to settlements	958.89
Forest III to settlements	0
Forest IV to settlements	0
Forest I to other lands	0
Forest II to other lands	1,917.79
Forest III to other lands	0
Forest IV to other lands	958.89
Forest I to wetlands and bodies of water	0
Forest II to wetlands and bodies of water	0
Forest III to wetlands and bodies of water	0
Forest IV to wetlands and bodies of water	0

Source of data and description of measurement /calculation methods and procedures applied:

The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez.

For the identification of deforestation, plots were identified in which, during the 2018-2020 period, they lost their entire forest cover or suffered a degradation process greater than 70% loss of the elements corresponding to trees.

After interpreting the 11,369 and labeling the change, a filter was made to identify those points that were deforestation. 47 points were identified within the program area, to then use the equation found in section 3.1.1 to obtain the data on hectares of deforestation. For monitoring, a total of 47 deforestation points were identified, which is equivalent to a total of 42,068.05 ha.

After the identification of the deforested plots, the forest stratum was identified for each of the plots and the carbon content was assigned. Then, the non-forest cover to which the plot passed was identified and the carbon content for this use was assigned.

The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".

https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

<table>
<tr><td></td><td>In the tab Program Report 18-20 and column D, in the section corresponding to Deforestation is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the year’s corresponding to the monitoring.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>A review of the non-logical changes was made and the information corresponding to the land cover that did not match was updated.

For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>Table 56. Uncertainties for deforestation in the monitoring period
<table>
<tr><th>Classification</th><th>Deforestation</th></tr>
<tr><td>Median</td><td>44,951.1</td></tr>
<tr><td>Average</td><td>45,032.8</td></tr>
<tr><td>Deviation</td><td>42,905,355.4</td></tr>
<tr><td>CI – lower limit</td><td>32,024.6</td></tr>
<tr><td>CI – upper limit</td><td>58,084.9</td></tr>
<tr><td>%</td><td>29.0</td></tr>
</table></td></tr>
<tr><td>Any comment:</td><td>To access the documents and calculations related to this activity, consult the following link:
Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link</td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>Degradation</td></tr>
<tr><td>Description:</td><td>Degraded forest land
The following equations were used to calculate this parameter:
Activity data: Equation 14
Additionally, to convert the data to emissions we used equation 1<i>9</i>.</td></tr>
<tr><td>Data unit:</td><td>Hectare</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>Table 57. Average hectares per year that have been degraded within the 2016-2020 period
<table>
<tr><th>Classification</th><th>(Ha)</th></tr>
<tr><td>Forest I (>70%) to degraded (70-30%)</td><td>14,383</td></tr>
<tr><td>Forest II (>70%) to degraded (70-30%)</td><td>32,602</td></tr>
<tr><td>Forest III (>70%) to degraded (70-30%)</td><td>23,013</td></tr>
<tr><td>Forest IV (>70%) to degraded (70-30%)</td><td>14,383</td></tr>
</table></td></tr>
<tr><td>Source of data and description of measurement</td><td>The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez</td></tr>
</table>

/calculation methods and procedures applied:

For degradation, the three interpreters identified a total of 88 points within the four forest strata that were identified for Guatemala. Of these 88 points, 15 correspond to Stratum 1, 34 to Stratum II, 24 to Stratum III and finally 15 to Stratum IV.

This analysis is performed on forest land that is maintained as such. To identify plots with forest degradation, the following equation is used:

$$Degradation = 100 * \frac{Year\ 2020 * 100}{Year\ 2016}$$

The analysis is done at the grid points, which remain as forest land or forest. Subsequently, the analysis of the loss of the elements that were categorized as trees is made. If the point loses between 30% and 70% of the trees, it is categorized as forest degradation.

The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".

In the Program Report 18-20 tab and column D of the Degradation section (Rows 45-48) is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the years corresponding to the monitoring.

QA/QC procedures applied:

For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.

Uncertainty for this parameter:

Table 58. Uncertainties of degradation in the monitoring period

Classification	Degradation
Median	84,301.2
Average	84,214.0
Deviation	80,521,353.3
CI – lower limit	66,956.1
CI – upper limit	102,067.1
%	20.8

Any comment:

To access the documents and calculations related to this activity, consult the following link:

Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

Parameter: Forest Degradation Recovery

<table>
<tr><td>Description:</td><td>Land recovered from forest degradation
The following equations were used to calculate this parameter:
Activity data: Equation 15
Additionally, to convert the data to emissions we used equation 20.</td></tr>
<tr><td>Data unit:</td><td>Hectares</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>Table 59. Hectares per year of forest increments through forest restoration.
<table>
<tr><th>Classification</th><th>(Ha)</th></tr>
<tr><td>Forest I restored</td><td>52,739</td></tr>
<tr><td>Forest II restored</td><td>77,670</td></tr>
<tr><td>Forest III restored</td><td>54,657</td></tr>
<tr><td>Forest IV restored</td><td>19,178</td></tr>
</table></td></tr>
<tr><td>Source of data and description of measurement /calculation methods and procedures applied:</td><td>To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez

To calculate the recovery from degradation, a total of 213 points were identified in the four forest strata of the program. Of these 213 points, 55 correspond to Stratum I, 81 to Stratum II, 57 to Stratum III and 20 to Stratum IV. It is important that this analysis is done within the points that maintain their forest cover, and that recover 30% to 70% of the elements corresponding to trees. To carry out this analysis, the following equation is used:
$$Degradation\ recovery = 100 * (\frac{Year\ 2016 * 100}{Year\ 2020})$$

After knowing the total number of points that were identified as recovery from degradation, the equation found in section 3.1.3 was used to obtain the data in hectares, and then divided by two years to obtain the data in hectares per year.

The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

In the Program Report 18-20 tab and column D of the Degradation section (Rows 49-52) is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the years corresponding to the monitoring</td></tr>
</table>

<table>
<tr><td>QA/QC procedures applied:</td><td>For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>Table 60. Restoration uncertainties of degraded areas
<table>
<tr><th>Classification</th><th>Restoration</th></tr>
<tr><td>Median</td><td>204,288.9</td></tr>
<tr><td>Average</td><td>204,262.6</td></tr>
<tr><td>Deviation</td><td>190,715,024.6</td></tr>
<tr><td>CI – lower limit</td><td>176,772.0</td></tr>
<tr><td>CI – upper limit</td><td>232,084.8</td></tr>
<tr><td>%</td><td>13.5</td></tr>
</table></td></tr>
<tr><td>Any comment:</td><td>To access the documents and calculations related to this activity, consult the following link:
Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link
Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link</td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>Increased Carbon Through Forest Plantations</td></tr>
<tr><td>Description:</td><td>Increased Carbon Through Forest Plantations
The following equations were used to calculate this parameter:
Activity data: Equation 15
Additionally, to convert the data to emissions we used equation 20.</td></tr>
<tr><td>Data unit:</td><td>Hectares</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>Table 61. Hectares per year of carbon increases through forest plantations.
<table>
<tr><th>Classification</th><th>(Ha)</th></tr>
<tr><td>Profit Coniferous Plantations</td><td>959</td></tr>
<tr><td>Profit Broadleaf Plantations</td><td>-</td></tr>
</table></td></tr>
<tr><td>Source of data and description of measurement /calculation methods and</td><td>To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link</td></tr>
</table>

<table>
<tr><td>procedures applied:</td><td>The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez.

Regarding the information on forest plantations, only one plot corresponding to coniferous plantations was identified. To obtain the data per hectare, the equation found in section 3.1.4 was used.

The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir".
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

In the Program Report 18-20 tab and column D of the Degradation section (Row 53) is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the years corresponding to the monitoring.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>Table 62. Forest plantation uncertainties
<table>
<tr><th>Classification</th><th>Plantations</th></tr>
<tr><td>Median</td><td>973.8</td></tr>
<tr><td>Average</td><td>977.6</td></tr>
<tr><td>Deviation</td><td>907,138.1</td></tr>
<tr><td>CI – lower limit</td><td>- 916.5</td></tr>
<tr><td>CI – upper limit</td><td>2,853.4</td></tr>
<tr><td>%</td><td>193.6</td></tr>
</table></td></tr>
<tr><td>Any comment:</td><td>To access the documents and calculations related to this activity, consult the following link:
Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link</td></tr>
</table>

9.2 Organizational structure for measurement, monitoring and reporting

- **Organizational structure**

The MRV system of the forest sector has been built according to the capacities in the country to respond to the UNFCCC from the international point of view, and at the national level based on existing platforms, studies, data and processes, taking into account a diversity of governmental and non-governmental institutions, including academia, research centers and civil society organizations. In addition, it is based on the current legal frameworks: Forestry Law (Decree 101-96), Law of Protected Areas (Decree 4-89), and the Framework Law to Regulate the Reduction of Vulnerability, the Mandatory Adaptation to the Effects of Climate Change and Greenhouse Gas Mitigation (Decree 7-2013). These laws mandate the different government institutions to collect and process information according to their scope of action.

The MRV system for the Emission Reduction Program has been implemented through coordination by INAB, as the Executing Unit of the Program, with the support of technical staff from the GIS units and the climate change units/departments/ directorates of the institutions that make up CONAP, INAB, MARN and MAGA, as well as representatives of the Guatecarbon, Forests for Life and Local Networks (REDDES) REDD+ projects. The preparation of this report was complemented with the support of specialists from U*niversidad del Valle de Guatemala* [30]for carbon accounting.

All the information generated by the different institutions was integrated and systematized by INAB within the framework of the ERPA of the ER Program under the FCPF. In this sense, INAB has been an integrating unit and generator of the reports before the FCPF. It is in close coordination with MARN, as focal point before the UNFCCC, to ensure consistency between the information generated in the framework of the ERP and what is reported for other initiatives and commitments under the United Nations Framework Convention on Climate Change (UNFCCC), including GHG inventories for the LULUCF sector.

It is important to point out that each government institution of the Interinstitutional Coordination Group GCI[31] for the preparation of the First Emissions Reduction Monitoring Report has provided different inputs according to their competencies. A brief description of them is made in Table 1 below.

Table 63. Participating institutions in the elaboration of the First Emissions Reduction Monitoring Report and the inputs provided.

Institution	Inputs
INAB / Emission Reduction Program Executing Entity (Coordinatior, Technical coordinatior, departments of GIS and Climate change)	Coordinate ER monitoring report integration
	Forest Cover Maps (in collaboration with CONAP).
	National Forest Inventory.
	List with information and maps/polygons on the areas subject to incentives by PINPEP, PINFOR, and PROBOSQUE.
	Data, maps and/or polygons linked to the use of firewood and legal and illegal selective logging.
	Estimation of average annual increments (AAI), and removals due to increased carbon stocks at the national level, through forest management and reforestation (management of natural forests, plantations, AFSs, forestry incentives) and natural regeneration.
	Emission factors for degradation and Removal factors for increases in carbon stocks.
	Participate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.
CONAP / Climate Change Unit and the Geospatial Analysis Directorate, Center for Evaluation and Monitoring (CEMEC) located in Petén.	Forest Cover Maps (in collaboration with INAB) Forest fires data Participate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.?

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[30] Second monitoring report will be supported by UVG and a capacity building process will take place during 2023 for INAB to be full responsible of implementing the third MR with support from other institutions.

[31] GCI is the institutional governance body for REDD+ implementation in Guatemala.

MAGA / Geographic, Strategic Information and Risk Management and Climate Change Unit.	Develop anciliary datta such as vegetation cover and land use maps, for a potential estimate of carbon in the land uses. Suppor monitoring report integration.
MARN / Science and Metrics Department and the Mitigation Department of the Climate Change Unit, as well as in the Environmental Information and Climate Change Unit.	Reference Level of National Emissions for the Forest Sector and other land uses.
	Staff to standardize and ensure that there is consistency in the data presented in the ERP before the FCPF, the Greenhouse Gas Inventories (GHGIs), the reference level presented to the UNFCCC and the Registry of Projects for the Removal or Reduction of Greenhouse Gas (GHG) Emissions. Coordinate on visual interpretation of sample units of the national grid for generating LULUC Activity Data.
REDD+ Projects Guatecarbon, Forests for Life, Networks for Local Development (REDDES)	Technical staff
	Data from REDD+ projects, polygon activities, etc.
	Community monitoring data.
	Relevant scientific studies and research.
	Complaints linked to drivers of deforestation and forest degradation.
Universidad del Valle de Guatemala	Support on carbon accounting, data procesing… Support on visual interpretation of sample units of the national grid for generating LULUC Activity Data. Support on ER monitoring reor development. Support on uncertainty and sensitivity analisys.

- **Selection and management of GHG related data and information**

Data selection and management was done to maintain consistency with the FREL included in the ERPD[32], and with the national FREL presented to UNFCCC[33]. This process was done by the GCI taking into consideration to use the best data available at the moment of generating the report which may also be available with the quality and in time to generate future reports. For the measurement and monitoring of activity data it is based on statistical sampling geo referencing of the territory using high and medium resolution sensors for the monitoring of forest cover, land use and land use change (LULUCF).

This approach is done by visual interpretation of samples, is easy to update for each monitoring period. Emission Factors are based on carbon strata map[34] which has been developed with the systematization and analysis of the best national data on carbon in the aerial and underground biomass of forests, from forest inventories in the country with different purposes and the first cycle of the National Forest Inventory of Guatemala, with the application of allometric models suitable for the country and its relationship with its bioclimatic variables.

The absorption factors (FA) are those estimated for the increase in carbon stocks by the annual growth of forest masses. They are obtained from the parcel system permanent sampling (PPM) established in the forestry incentive programs, with growth models applied to different species (pine and broadleaf).

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[32] https://www.forestcarbonpartnership.org/system/files/documents/guatemala_erpd_11_05_2019.pdf

[33] https://redd.unfccc.int/files/niveles_referencia_emisiones_forestales_guatemala_070222.pdf

[34] https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link

- **Processes for collecting, processing, consolidating and reporting GHG data and information**

The process of MRV in the ERP is implemented following the IPCC general equation of using Emission and Absorption Factors (related to forest inventory data) combined with Activity Data (related to remote sensing data) to estimate emissions and absorptions. A general approach of MRv in Guatemala is summarized in Figure 1.

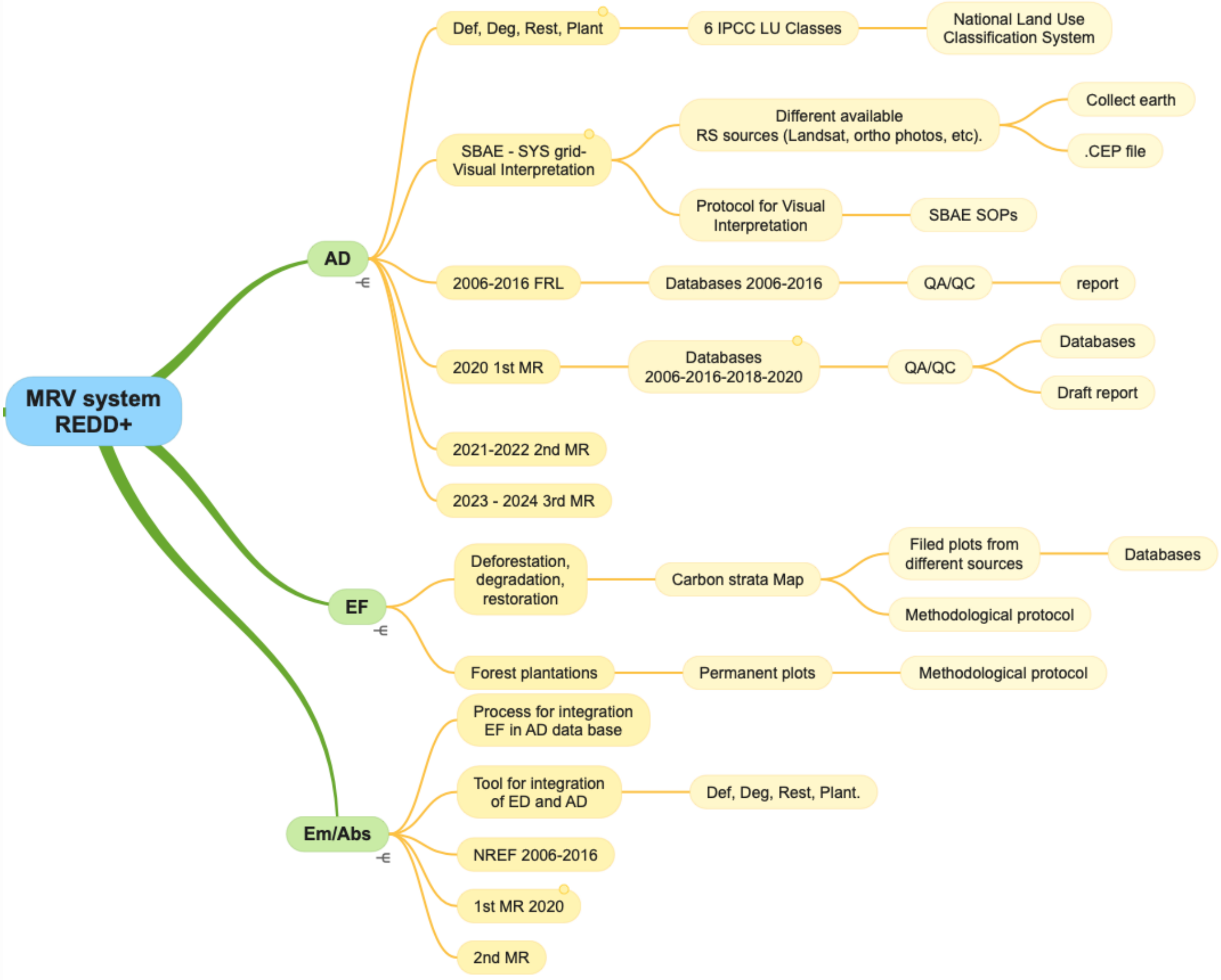

Figure 9. General approach for MRV for REDD+ in Guatemala ERP

- **Activity Data (AD)**

For the collection of activity data under the ERPA, the land use categories of the Intergovernmental Panel on Climate Change (IPCC) were used for the assignment of land cover for each of the plots.

Activity data for reporting emission reductions in deforestation, degradation and carbon stock increases were monitored under the ERPA, reported using data generated using a Sample Based Área estimation through the use of a visually interpreted grid of sampling points developed with the Collect Earth platform[35] and using images available in

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[35] https://openforis.org/tools/collect-earth/

high resolution (Digital globe, Planet, Aster, Sentinel, etc.), as well as medium resolution Landsat images (Table 2). This grid represents a geo-referenced statistical sampling of the territory and corresponds to a comprehensive approach to multi-temporal monitoring of forests and other land uses, which provides, during the ERP period, a specific and geographically-explicit analysis of the changes in the surfaces due to processes of deforestation, degradation and stock increases. Its use ensures consistency with the Forest Reference Emission Level (FREL). Currently, the grid activity data is generated every two years and the monitoring sample is 10,414 points, corresponding to the subnational area of the FCPF program.

These new activity data generated with the Collect Earth Desktop tool will be used to generate the next GHG Greenhouse Gas Inventories that will be contained within the Biennial Reports and the new National Communications that will be generated in the future, the previous four GHG Inventories GHG Greenhouse Gases that have been generated in Guatemala were prepared with methodologies other than sampling.

The grid is part of a comprehensive monitoring system for forests and other land uses, since it is complemented with the maps generated every five years to improve the cartographic model and increase its thematic accuracy and change detection (reduces uncertainty) to provide national statistics and international reports, see Table 264 and Table 65.

Table 64. *Main activity data inputs of the MRV System for deforestation, degradation and increases.*

Inputs	Type of Information	Scale/Resolution/Sampling Unit	Frequency	Source/Protocols
Point sampling grid for forest monitoring	Geodatabase with variables of forest cover and land use dynamics	National grid of 3.1 X 3.1 km for visual interpretation in medium and high resolution images (11,369 sampling points) for the entire country, regarding the FCPF program area, the total points correspond to a total of 10,414.	Multi-temporal evaluation of coverage and change of use every 2 years	GIMBUT, 2018
RS images	Collection of remote sensing images (Digital Glob, Airbus, INEG, AfriGIS, CNES)	Median: 30 m (Landsat, 5,7 and 8) High: 1.24 m to 5 m (Spot, WorldView, Rapid eye, Quick Bird, Sentinel, etc.)	Period of 15 days, Monthly, Annual	Google Earth, Engine and Bing Maps with the use of the Collect Earth platform (FAO, 2015)
	The orthophotos of Guatemala.	High resolution: 0.3 meters.	Only one year corresponding to the months of October, November and December 2006.	http://ide.segeplan.gob.gt/cgi-bin/mapserv.exe?map=/ot_web/ot_overview_1.map&SERVICE=WMS&

- **Emission/Absorption Factors (EF/AF)**

Access to the Guatemalan information collection form: https://drive.google.com/drive/folders/1IhxjFz5gPGKg-qCbXXBwU9cDOSnQ0E5m?usp=drive_link

Regarding emission factors, the same ones used in the FREL were used. These are based on the carbon strata map, which presents the best national data on biomass carbon in forests, as a result of a systematization and analysis of forest inventories for different purposes, allometric models and bioclimatic variables, combined with national and default (IPCC) values on the non forest strata.

The absorption factors used for the MRV are the same ones used for the increases in carbon stocks that come from permanent sites in forest plantations of forestry incentive programs (INAB) with growth models for different species and that are used for the estimation of emissions in areas where a change from other lands to forest lands due to a plantation is detected. The main inputs for the emission and absorption factors of the MRV system and their characteristics are described in Table 3.

Table 65. Main inputs of emission and absorption factors of the MRV System for deforestation, degradation and increases.

	Inputs	**Type of Information**	**Scale/Resolution/Sampling Unit**	**Source/Protocols**
Emission Factors	Carbon Strata Map	Raster and Vector Geodatabases	1 ha	GIMBUT, 2017; Gómez Xutuc 2017.
	Carbon density of land use in agriculture, livestock use and agroforestry systems	Databases and estimation process in the Quantification of carbon. Specific studies.	Districts of crop producers and agroforestry systems	ANACAFÉ 1998, Castillo 2006
	Non-forest carbon contents	Default emission factors	National/ By type of climatic region	IPCC, 2006; IPCC, 2019
Absorption Factors	Permanent plots	Databases	Plots in forest plantations	INAB, 2012. Samudio 2017.
	Growth models	Average annual increments and absorption factors	National (forest plantations)	INAB, 2012. Samudio 2017.

It is important to mention that the carbon strata map has the limitation of not being dynamic and depending on the availability of updating new forest measurement plots or remeasurements of the analyzed plots, which makes its long-term use very complex. Therefore, it is important to make a substantial improvement in the MRV for emission and removal factors in the medium term[36]. For this, a National Forest Inventory for multiple purposes has already been launched, where a network of 715 sites has been established where variables related to the carbon content of biomass above ground, below ground and of dead organic matter, with a design of three secondary sampling units will be collected.

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[36] Not to be implemented during the ERP period.

Regarding the monitoring report, the Working Group for the Preparation of the First ER Report of Guatemala processes the information and results of the estimates resulting from the analysis of the activity data and emission factors during the period of the ER Program and, then, subsequently transfers them to INAB so that it prepares the report to the FCPF (Figure 2). In turn, INAB transfers them to MARN for the report to the UNFCCC.

Role of users, beneficiaries and communities in forest monitoring system

Forest community monitoring in the country during the year 2020 due to COVID-19 has been constituted from the local perspective in the primary source of information on the state of the forest, the natural resources associated with the ecosystem and the social and economic conditions of the communities directly and indirectly linked to the use and exploitation of these resources.

The Government of Guatemala has worked on the construction of a computer tool that is part of an early warning system for the prevention and control of deforestation and forest degradation. This tool was developed in the MRV of the National Climate Change System of Information (*SNICC, for its acronym in Spanish*) and also in a mobile application for smartphones aimed at providing information in the field to different users with and without Internet access. The development of this tool also seeks to support the operationalization of this system through the participation of local governments under the operational scheme of community monitoring of the country's National REDD+ Strategy. This information is available at the following link: https://snicc.marn.gob.gt/MRV/SNMF

The community forest monitoring system contributes to the monitoring of social and environmental safeguards and the implementation of actions developed locally in the program. However, it does not participate in the monitoring of carbon variables. Below is a brief description of the role of community monitoring in 2020 in the different REDD+ Projects:

1. **Guatecarbon**: Through a community monitoring network made up of commissions for the control and protection of forest fires and a scientific commission on biodiversity, they have carried out monitoring of environmental and social issues in 11 communities of the Maya Biosphere Reserve, with a scope of at least 6,000 direct beneficiaries of the ERP.

2. **Forests for Life:** Through local workshops through community monitoring in the Sierra Lacandón Park, where the environmental and social issues of the ERP have been monitored, in at least three local communities and 120 direct beneficiaries of the program.

3. **Local Networks for Development (REDDES):** Actions were implemented to support the reduction of deforestation, degradation and increase of forest cover in 12 municipalities of the departments of Alta Verapaz, Quiché and Huehuetenango, to ensure the environmental goods and services that forests provide to indigenous communities and local organizations. These monitoring actions were carried out in at least 31 communities.

Community monitoring in the program is a process that is constantly being improved, since the participation of the local community has not yet been fully achieved. This is something that the government will work on in conjunction with the REDD+ Projects, to ensure that all activities are standardized and documented for the beneficiary communities. The Guatemalan MRV System will continue with the dynamic of empowering communities to gradually measure, monitor and report carbon stocks and, at the same time, that these activities contribute to local livelihoods and the conservation of forest biodiversity.

9.3 Relation and consistency with the National Forest Monitoring System

The MRV system for the carbon and emissions components in the LULUCF sector is part of the National Information System for GHG Emissions, Multiple Benefits, Other Impacts, Management and REDD+ Safeguards (*SIREDD+*), which represents the institutional proposal within the framework of the National REDD+ Strategy for Guatemala (2020-2050). SIREDD+, in turn, is part of the National GHG Inventory System (*SNIGT*), which is part of the SNICC (See Figure 6).

The SNICC aims to collect, systematize, analyze and present all the information related to climate change at the national level, including: Climate science, vulnerability, loss and damage; adaptation to climate change; GHG emissions and removals; and, mitigation measures. This information may be used for sectoral and territorial planning processes, monitoring and reporting of the country's progress, public investment programming and the formulation of public policies and application instruments on climate change. Therefore, the SNICC represents the set of data and information generated and analyzed, the necessary governance for the generation, analysis and reporting of this information and the virtual platforms that display it and make it public for the different users (Draft 1IBA, 2022).

All the country's climate change monitoring systems are incorporated under the SNICC, so that the order and quality of the information can be ensured. Since monitoring related to REDD+ is part of this structure, consistency is ensured both with the country's LULUCF sector monitoring system and with the entire national climate change monitoring scheme, including the Registry of Projects for the Removal or Reduction of Greenhouse Gas (GHG) Emissions (Figure 10).

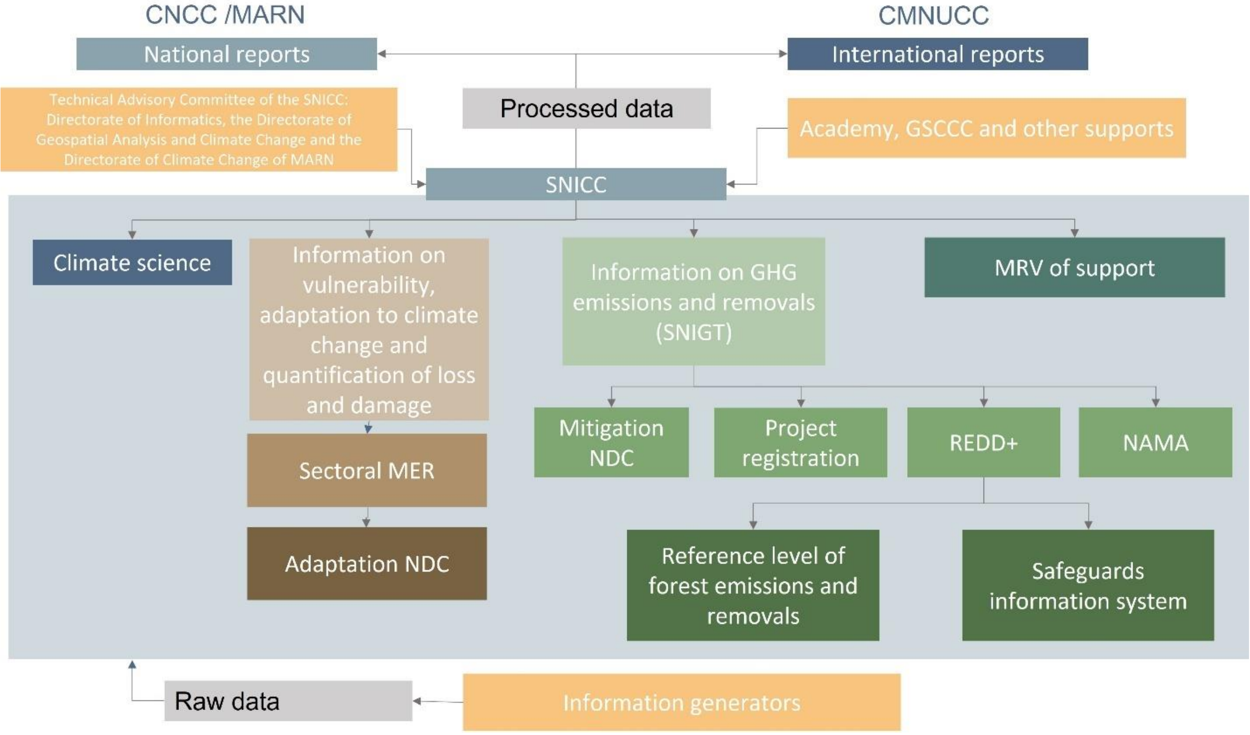

Figure10. Operation and subsystems of the SNICC

12 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

12.1 Identification and assessment of sources of uncertainty

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Activity Data						
Measurement		X	In the case of Guatemala, according to the sampling carried out for the generation of activity data, there may be sources of error associated with the quality and resolution of satellite images, the visual interpretation of samples, and sampling design. The error associated with the quality and resolution of the images could be considered low, since medium and high-resolution images have been used and the size of the analyzed plot (1ha) allows a correct visual interpretation of the images. In addition, the use of the Collect Earth tool allows to visualize the best images available on the dates of interest, ensuring to have images without clouds and with the requirements for their proper interpretation and reducing as much as possible the uncertainty that originates from this source. Another source of uncertainty comes from the main process for the estimation of the DA which is the visual interpretation of each of the points of the grid, for this part there has been a series of processes to minimize errors, with the choice of professional interpreters, who have gone through a training process on the use of the tools, an interpretation protocol has been developed which is the basis for the definition of classes.	High	Yes	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			In addition, some scripts have been programmed to facilitate interpretation and avoid making mistakes during this process; a reliability value is even assigned to each of the data that is collected at each point in the mesh. Finally, a review of 5% of the samples is made by 3 interpreters and a comparative matrix of each evaluated point is made and a percentage of error is obtained in the interpretation of each of the original interpreters. For the measurement of the four REDD+ activities in Guatemala: A mesh composed of 11,369 samples was used, which was used both at the reference level and in the first monitoring. With the sample mesh, the objective was to collect the land cover using the six IPCC classes and which were entered into a Collec Earth desktop form to display and interpret the high-resolution images for the year of study. Each plot on the Collect Earth form was made up of 25 elements for which coverage was assigned based on these elements, which could be trees, grasslands, agricultural land, bare soil, bodies of water and wetlands, as well as other land. In this way, each one of the interpreters was assigned a total of 3,700 plots (average) for each one to carry out the visual interpretation using the high-resolution images of Google Earth that were synchronized with Collect Earth. The imagery source was primarily high-resolution Google Earth imagery, followed by Planet, Sentinel, and Landsat imagery only when no imagery was available in Google Earth, or there were clouds or shadows in the Google Earth image.			

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			After the interpretation of the 11,369, the classes of change or permanence were identified with labels to identify deforestation, degradation, and carbon increases through recovery from degradation and forest plantations. In this exercise, a review was made to assess the consistency of the coverage of the plot and whether it was coherent with the other dates. This process was carried out in an Excel sheet. After processing the labels, the total points for each of the four activities of the program were counted and then in another Excel tool to calculate hectares, total carbon and finally to be able to calculate the total number of CO2 emissions and absorptions. To reduce the error derived from visual interpretation, the Collect Earth methodological protocol was used to homogenize criteria among the interpreters, a forum was created in which the interpreters, when they had a sample with great difficulty, helped each other and how exercises were also done. to assess the degree of agreement between them as part of quality control. For the interpretation of the plots, 638 plots were interpreted and the information was cross-checked to obtain the percentage of coincidence between the three interpreters. Due to the restrictions derived from the COVID-19 pandemic, the interpreters worked remotely, sending their results every 15 days to be reviewed. It is important to mention that among the interpreters there was communication with them to resolve doubts if the plot was too difficult to interpret.			

Sources of uncertainty	**Systematic**	**Random**	**Analysis of contribution to overall uncertainty**	**Contribution to overall uncertainty (High / Low)**	**Addressed through QA/QC?**	**Residual uncertainty estimated?**
			The temporal analysis was also done to identify possible incongruent transitions since having four points in time allowed to find out those non-logical changes that the plot could obtain. All this process was carried out using the Excel tool to process the information. When these non-logical changes were identified, the plot was reviewed again and the information was edited to ensure that the plot information was correct. Of the total of 638 samples for transitions and permanence that were identified for both the first monitoring and the reference level that was reviewed. For deforestation and degradation, 48 and 42 samples were established, while for carbon increments through degradation recovery and plantations, the samples were 56 and 18 respectively. These subsequent samples were chosen randomly and with a confidence interval of 95% and an error of 5%. Finally, it is important to mention that it can be considered that the interpreters do not have the same experience to interpret satellite images, so it is possible that the interpretation error is high.			
Representative ness			To detect areas of change due to emissions and removals from deforestation, degradation, and increases in carbon stocks, Guatemala used a multipurpose grid to collect information. This grid was prepared in the context of the second forest inventory of Guatemala, which seeks to be able to represent the soil cover with a sampling precision of 10% with a confidence interval of 95%, which is sufficient with 672 samples.	Low	Yes	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			With this information, Guatemala decided to use a 3.1x3.1 grid system using a non-aligned systematic sampling design, making the sample proportional to the country's area. Within each grid, a randomly located point was located, thus allowing the evaluation of the change in use of the land cover. The grid design generated a total of 11,369 points located randomly within each grid for the entire surface of the country. After locating the 11,369 samples, a Collect Earth form was generated to collect the information using high-resolution images found in the Google Earth image catalog. In the event that a High Resolution image is not available, images from the Landsat, Sentinel or Planet family are used depending on their availability. This Collect Earth form asked about the six IPCC classes as well as other land cover based on the land cover mapping of Guatemala. If, in case, a change was detected, the form indicated what kind of coverage it went to, as well as the year and the sensor with which the information was captured. Within the actions to minimize the error due to the collection of information, Guatemala generated an interpretation protocol so that each specialist or interpreter could address it in case they had doubts when choosing the land cover. Monthly meetings were also held to resolve doubts that had a high degree of interpretation, but since most of the images are of high resolution, it can be considered that the protection against uncertainty due to the collection of information is low.			
Sampling			Regarding sampling error, this is the type of error that is quantified for its propagation in uncertainty, the sampling	Low	Yes	Yes

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			design is systematic with a mesh of 3.1 km x 3.1 km with a site located within each of the quadrants of the mesh. With the density of the sample you have, it is enough to capture the dynamics of the forests with an acceptable error. However, if you wanted to make an estimate of a smaller area, or for a specific type of change, this would require a densification of the mesh in those areas of interest. The value used for uncertainty propagation is the sampling error that comes from the activity data for each of the transitions that are identified.			
Extrapolation			Not apply			
Approach 3			This source of uncertainty is not applicable. Activity data were estimated conducting tracking of lands or IPCC Approach 3 for reference and monitoring periods	High	Yes	No
Emission Factor						
DAP measurement		X	The measurement of the DAP was measured directly since information from different forest inventories that various projects in Guatemala have implemented over time was used. In Guatemala, a tree is defined as having a DAP greater than 10 centimeters at breast height. Being information coming from various sources of forest inventories, there is no estimate of random or systematic errors that can contribute to the total uncertainty, because what can be considered high contribution.	High	No	No
H measurment		X	The allometric equations used to generate the carbon strata map do not use height to estimate carbon content.	High	No	No
Plot delination		X	The use of plots of different origins and sizes leads to considerable errors, in addition to the fact that each group of plots has different purposes and therefore different	High	No	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			types of sampling, gives us an idea that EFs are one of the main sources of uncertainty in the estimation of emissions and removals. In this case, weightings were made according to the size of the different plots and the values were used to generate a map of carbon strata. In this process, modeling was done with the Monte Carlo and Bootstrap method to better represent the distribution functions of the sample used, which means that the errors of each FE reported on the map become considerably low (see the FE section and the Carbon Strata Map protocol). There was no control over the size and shape of the plot, nor in the process of plot establishment.			
Biomass allometric model		X	For the calculation of biomass, three allometric equations were used for natural forests, both broadleaf and coniferous, the latter were standardized through studies carried out by the Universidad del Valle de Guatemala: UVG (2015) for coniferous, UVG (2015) for broadleaf ; and for the northern lowlands the equation of Williams Arreaga (2002), with these the aerial biomass was calculated for each tree (includes from the stem to the branches), using only the DAP (diameter at height of 1.3 m). In the case of the mangrove forest, three equations were applied according to the species found (permanent sampling plots from the southern coast of Guatemala administered by INAB were used).	High	No	No
Sampling			The sampling design for the calculation of forest carbon of the plots varies since there are data from plots with a size ranging from 0.02 to 1 hectare in size of the plot, this because the collection of more than 3,000 plots distributed in most of Guatemala and covering more than 203 thousand	High	No	Yes

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			trees that were inventoried. Derived from the fact that this information also comes from various information sources and it is not clear if there were quality control processes, this causes the contribution of sampling uncertainty to be high. For the propagation of the error, the probabilistic density function values were used for each of the carbon strata and for each of the different plot sizes with which the four strata of the carbon map were developed.			
Other parameters (e.g. Carbon Fraction, rootto-shoot ratios)			For the carbon fraction, the IPCC factor 0.47 was used, while to establish the belowground carbon fraction, the Mokany equation was used because it was established that this equation was the most appropriate in proportion to the area biomass. Using the forest carbon content per hectare, the Mokany equation was applied to obtain the proportion of subterranean carbon. This information is integrated in the carbon strata map so that the error cannot be propagated.	High	Yes	No
Representativeness			The map of carbon strata covers the entire territory since plots from different forest inventories in Guatemala were used to ensure that forest carbon is represented on the map. Also, as part of the review by the UNFCCC reference level, an analysis was made on the correspondence of the map information with INAB's physical plots (document included in annexed folder 01.Datos_Fuentes/01. Carbono_forestal/Mapa Estratos de Carbono / 01_ControCalidad).	High	Yes	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Integration						
Model			There is an Excel file containing all the variables to estimate the uncertainty of the reductions. We will be working for the second monitoring in a manual to perform this calculation. All sources of error were quantified in the activity data and emission factors, which were propagated in the integration, so it is assumed that the uncertainty calculation will be low. In addition, a logic function was performed within the tool to estimate emissions/removals to verify that the total area of the points coincides with the total area of the program.	Low	No	No
Integration			Emission factors were calculated for each forest stratum according to the location of the dot mesh plots to ensure comparability between the transition classes of activity data and those of emission factors. This source of uncertainty is considered as one of the main sources of uncertainty.	High	Yes	No

12.2 Quantification of uncertainty in Reference Level Setting

Parameters and assumptions used in the Monte Carlo method

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Reference Level (RL)					
Forest carbon content (tonC/ha)					
Forest carbon content -Strate I-	0.03	k = 1.553; beta = 106.475	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
	0.04	µ = 220.867; sigma = 30.44	Error due to different sizes of forest stands used to calculate carbon content.	Normal	Minimum value assumed to be 0
	0.05	gamma = 82.476; beta = 1.647; µ = 12.195	Error due to different sizes of forest stands used to calculate carbon content.	Weibull (3)	Minimum value assumed to be 0
	0.1	gamma = 124.079; beta = 2.329	Error due to different sizes of forest stands used to calculate carbon content.	Weibull (2)	Minimum value assumed to be 0
	0.13	µ = 346.731; sigma = 30.352	Error due to different sizes of forest stands used to calculate carbon content.	Normal	Minimum value assumed to be 0
	0.25	µ = 116.878; s = 16.518	Error due to different sizes of forest stands used to calculate carbon content.	Logística	Minimum value assumed to be 0
	1	µ = 101.778; s = 12.542	Error due to different sizes of forest stands used to calculate carbon content.	Logística	Minimum value assumed to be 0

	2	alfa = 0.432;
		beta = 0.641;
		c = 7.854;
		d = 75.214
			Error due to different sizes of forest stands used to calculate carbon content.	Beta4	Minimum value assumed to be 0

Forest carbon content	0.03	µ = 4.329; sigma = 1.065	Error due to different sizes of	Log-normal	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
-Strate II-			forest stands used to calculate carbon content.		
	0.05	µ = 4.656; sigma = 1.04	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	0.1	Gamma = -0.071 beta = 53.543; µ = 73.854	Error due to different sizes of forest stands used to calculate carbon content.	GEV	Minimum value assumed to be 0
	0.25	µ = 4.566; sigma = 0.843	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	2	k = 0.42; beta = 86.609	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
Forest carbon content -Strate III-	0.03	µ = 4.787; sigma = 1.143	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	0.05	gamma = 85.775; beta = 1.08; µ = 17.098	Error due to different sizes of forest stands used to calculate carbon content.	Weibull (3)	Minimum value assumed to be 0
	0.1	µ = 4.735; sigma = 0.846	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	0.13	Gamma = -0.05 beta = 28.323; µ = 75.046	Error due to different sizes of forest stands used to calculate carbon content.	GEV	Minimum value assumed to be 0
	0.25	Gamma = -0.164 beta = 29.65; µ = 108.335	Error due to different sizes of forest stands used to calculate carbon content.	GEV	Minimum value assumed to be 0
	2	µ = 53.841; sigma = 36.152	Error due to different sizes of	Normal	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
			forest stands used to calculate carbon content.		
Forest carbon content -Strate IV-	0.03	k = 1.368; beta = 215.458	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
	0.04	gamma = 204.913; beta = 20.465	Error due to different sizes of forest stands used to calculate carbon content.	Weibull (2)	Minimum value assumed to be 0
	0.05	µ = 4.169; sigma = 0.703	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
	0.1	µ = 5.154; sigma = 1.051	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0

	0.12	alfa = 0.515;
		beta = 0.722;
		c = 109.721;
		d = 183.871
			Error due to different sizes of forest stands used to calculate carbon content.	Beta4	Minimum value assumed to be 0

	0.13	alfa = 0.327;
		beta = 0.246;
		c = 69.965;
		d = 160.387
			Error due to different sizes of forest stands used to calculate carbon content.	Beta4	Minimum value assumed to be 0

	2	k = 1.518; beta = 33.312	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
Conifer plantation	N/A	k = 2.597; beta = 3.468	Error due to different sizes of forest stands used to calculate carbon content.	Gamma (2)	Minimum value assumed to be 0
Broadleaf Plantation	N/A	µ = 1.247; sigma = 1.198	Error due to different sizes of forest stands used to calculate carbon content.	Log-normal	Minimum value assumed to be 0
Non-forest carbon content (tonC/ha)					

Parameter included in the model	Plot Size	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Annual agricultural land	N/A	4.7	IPCC default value	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Agricultural-coffee land	N/A	2.65	IPCC default value	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Agricultural land-African palm	N/A	2.4	IPCC default value	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Agricultural land-rubber	N/A	3	IPCC default value	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Agroforestry systems	N/A	20.1	Error due to different sizes of forest stands used to calculate carbon content.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Grasslands	N/A	6.73	IPCC default value	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Deforestation and degradation					
Carbon I stratum to annual agricultural land	N/A	Area (ha): 7,671.16 SD (ha): 2,711.25	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum II to annual agricultural land	N/A	Area (ha): 19,177.89 SD (ha): 4,284.39	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum III to annual agricultural land	N/A	Area (ha): 9,588.95 SD (ha): 3,030.98	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum IV to annual agricultural land	N/A	Area (ha): 6,712.26 SD (ha): 2,536.27	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon I stratum to agricultural-coffee land	N/A	Area (ha): 2,876.68 SD (ha): 3,255	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	
Carbon II stratum to agricultural-coffee land	N/A	Area (ha): 2,876.68 SD (ha): 1,660.69	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon III stratum to agricultural-coffee land	N/A	Area (ha): 0 SD (ha):0	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
Carbon IV stratum to agricultural-coffee land	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon I stratum to agricultural land-African palm	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon II stratum to agricultural land-African palm	N/A	Area (ha): 8,630.05 SD (ha): 2,875.58	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon III stratum to agricultural land-African palm	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon IV stratum to agricultural land-African palm	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon I stratum to agricultural land-rubber	N/A	Area (ha): 0 SD (ha): 0	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon II stratum to agricultural land-rubber	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon III stratum to agricultural land-rubber	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon IV stratum to agricultural land-rubber	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum I to agroforestry systems	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum II to agroforestry systems	N/A	Area (ha): 3,835.58 SD (ha): 1,917.51	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum III to agroforestry systems	N/A	Area (ha): 2,876.68 SD (ha): 1,660.69	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum IV to agroforestry systems	N/A	Area (ha): 3,835.58 SD (ha): 1,917.51	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
Carbon I stratum to grasslands	N/A	Area (ha): 79,588.26 SD (ha): 8,701.48	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon II stratum to grasslands	N/A	Area (ha): 71,917.11 SD (ha): 8,274.71	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon III stratum to grasslands	N/A	Area (ha): 31,643.53 SD (ha): 5,499.96	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon IV stratum to grasslands	N/A	Area (ha): 5,753.37 SD (ha): 2,348.24	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon I stratum to settlements	N/A	Area (ha): 1,917.79 SD (ha): 1,356.02	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon II stratum to settlements	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon III stratum to settlements	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon IV stratum to settlements	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum I to other lands	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum II to other lands	N/A	Area (ha): 2,876.68 SD (ha): 1,660.69	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum III to other lands	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum IV to other lands	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon I stratum to wetlands and water bodies	N/A	Area (ha): 958.89 SD (ha): 958.89	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon II stratum to wetlands and water bodies	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0

Parameter included in the model	**Plot Size**	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
Carbon III stratum to wetlands and water bodies	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon IV stratum to wetlands and water bodies	N/A	Area (ha):0 SD (ha):0	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Degraded Carbon I Stratum (>30% and <70%)	N/A	Area (ha): 34,520.21 SD (ha): 5,743.69	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Degraded Carbon II Stratum (>30% and <70%)	N/A	Area (ha): 83,423.84 SD (ha): 8,906.96	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Degraded Carbon III Stratum (>30% and <70%)	N/A	Area (ha): 51,780.32 SD (ha): 7,028.45	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Degraded Carbon IV Stratum (>30% and <70%)	N/A	Area (ha): 22,054.58 SD (ha): 4,593.84	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Increases in carbon stocks					
Carbon I stratum recovered from degradation (>30% and <70%)	N/A	Area (ha): 31,644 SD (ha): 5,500	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon II stratum recovered from degradation (>30% and <70%)	N/A	Area (ha): 35,479 SD (ha): 5,823	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon III stratum recovered from degradation (>30% and <70%)	N/A	Area (ha): 31,644 SD (ha): 5,500	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Carbon Stratum IV recovered from degradation (>30% and <70%)	N/A	Area (ha): 17,260 SD (ha): 4,065	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Non-forest land to coniferous plantations	N/A	Area (ha): 12,465.63 SD (ha): 3,455	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0
Non-forest land to broadleaf plantations	N/A	Area (ha): 15,342.32 SD (ha): 3,833	Error due to the interpretation of the grid.	Sampling errors are assumed to be normal.	Minimum value assumed to be 0

Quantification of the uncertainty of the estimate of the Reference level

		Deforestation	**Forest degradation**	**Enhancement of carbon stocks**
A	**Median**	26,393,854.80	6,226,826.61	-5,724,947.60
B	**Upper bound 90% CI** (Percentile 0.95)	14,309,347.15	2,557,345.59	-20,075,718.03
C	**Lower bound 90% CI** (Percentile 0.05)	55,359,133.61	16,793,666.05	501,933.27
D	**Half Width Confidence Interval at 90% (B – C / 2)**	-20,524,893.23	-7,118,160.23	-10,288,825.65
E	**Relative margin (D / A)**	78%	114%	180%
F	**Uncertainty discount**	12%	15%	15%

The MonterCarlo model can be accessed through the following link: https://docs.google.com/spreadsheets/d/1IvYDhAktIFUmb-FQC5r8h-ztr3yvEUP_/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

The model contains the following tabs:

- EstaAlmacenesPropError: parameters of forest and non-forest carbon contents.
- SimulForestSimul: simulations of forest carbon contents.
- Sions Report: Simulations of the emissions and removals of the monitoring period.
- RE: Simulation of emission reductions between the reference level and the monitoring period. mulNonForest: simulations of non-forest carbon contents.
- Deforest_Increment: simulations of emission and removal factors.
- DA NR: Simulations of reference level activity data.
- DA Report: Simulations of the monitoring period activity data.
- Emissions NR: Simulations of reference level emissions and removals.

For the model to run correctly in Excel, it is necessary to download and install the program NtRand, which allows to generate random numbers based on Mersenne Twister and provides several probability distributions and statistical utility functions and covers Monte Carlo VaR calculation.

NtRand can be downloaded using the following link: http://www.ntrand.com/

Sensitivity analysis and identification of areas of improvement of MRV system

The total uncertainty of emission reductions resulted in 72% in the four activities that have been implemented during the Emission Reduction Program stage. The uncertainties of each of the activities were distributed as follows:

- Deforestation: 77%
- Degradation: -132%
- Increments due to restoration: 117%
- Increments due to plantations: 80%

To determine the relative contribution of each parameter to the overall uncertainty, a sensitivity analysis was performed in which the REDD+ activities were selectively fixed and the Monte Carlo method was used to combine the uncertainties in the model simulations.

Table 31 shows the overall uncertainty of emission reductions shows that leaving the deforestation data fixed, the uncertainty of ER increases by 18%. Then the next parameter that increases the uncertainty is leaving the degradation data fixed, which increases the overall uncertainty by 6%. Forest degradation recovery and plantations do not have a significant impact on the overall uncertainty as there is a 1% reduction in the case for degradation recovery and 0% for plantations respectively.

Table 66. Senility analysis of emission reductions

Category	Percentage of uncertainty	Change with respect to general uncertainty
General uncertainty of emission reductions	72%	
Overall uncertainty of emission reductions -Keeping deforestation data fixed.	90%	-18% (increase)
Overall uncertainty of emission reductions -Keeping the degradation data fixed.	71%	1% (Decrease)
Overall uncertainty of emission reductions -Keeping the degradation recovery data fixed.	78%	-6% (Increase)
Overall uncertainty of emission reductions -Keeping the increase per plantation data fixed.	72%	0%

The negative data means an increase, since the general uncertainty data is being taken first to make the subtraction.

To view the sensitivity file (AnalsisiSensiblidad_v2), please click on the following link:
https://docs.google.com/spreadsheets/d/1IxFl5UbRkJFr1N20tpJY-xTROuN3hPbM/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

ANNEX 5: ER MONITORING REPORT (ER-MR) ON THE AREA OUTSIDE THE SCOPE OF ER PROGRAM ACCOUNTING AREA

This annex was prepared as part of the Government's commitment to monitor and report in parallel the annual reduction of emissions in the area outside the scope of the Emissions Reduction Program located in Triángulo de la Candelaria, Laguna del Tigre.

1.1 Carbon pools, sources and sinks

5.1.1. **Description *of Sources and Sinks selected***

Sources/Sinks	Included?
Emissions from deforestation	Yes
Emissions from forest degradation	No
Enhancement of carbon stocks	No
Sustainable management of forests	No
Conservation of carbon stocks	No

5.1.2. Description *of carbon pools and greenhouse gases selected*

Carbon Pools	Selected?

Above Ground Biomass (AGB)	Yes
Below Ground Biomass (BGB)	No
Biomass in non-woody vegetation	No
Dead organic matter	No
Soil Organic Carbon (SOC)	No

GHG	Selected?
CO2	Yes
CH4	No
N2O	No

1.2 REFERENCE LEVEL

5.1.3. Reference Period

The reference period is 2006-2016.

5.1.4. Forest definition used in the construction of the Reference Level

According to the national definition, the forest is the continuous area with dominant tree cover with a minimum canopy cover of 30%, forming a stand of a minimum of 0.5 hectares and a minimum width of 60 meters (GIMBUT 2018b). Forests and other land uses are defined below in the consistent representation of land with its classification criteria, to provide greater clarity in the quantification of the FREL, as well as in the characterization of the forest land dynamics processes that are identified from REDD+ activities in the FREL.

The definition of forest used differs from that used in the Forest Report Assessment (FRA) 2015, which is as follows: Forest land or land without any use that extends over 0.5 hectares, endowed with trees that reach a height greater than 5 m and a canopy cover greater than 10 percent. The term specifically excludes tree stands used in agricultural production systems, for example fruit plantations and agroforestry systems. The term also excludes trees that grow in urban parks and gardens.

On the other hand, the GHGI presented in the Third National Communication on Climate Change does not include a definition of forest, nor does it include the input used to detect deforestation. However, it can be assumed that operationally it should be similar due to the forest classifications identified, as well as to the other uses that are reported.

Although there could be differences in the definitions, operationally the definition has remained constant, since the classifications and figures reported in terms of the amount of forest, both in the FRA and in the National Communication are similar, and the differences can be attributed to the use of different inputs and methodologies, rather than to a difference in definition. In addition, the definition presented in this document will be used in the next official reports to the UNFCCC.

5.1.5. Average annual historical emissions over the Reference Period

5.1.5.1. Description of method used for calculating the average annual historical emissions over the Reference Period

The land use approach, in the three REDD+ activities of deforestation, degradation and increases in forest carbon stocks (IPCC, 2006). CO_{2eq} emissions and removals were obtained by multiplying the activity data corresponding to the area converted from forest land to other land for deforestation, the forest land that remains as forest land that loses coverage due to degradation, and the other land that is converted to forest land, through the recovery of degraded areas and the establishment of forest plantations to increase carbon stocks, by emission and absorption factors (Equation 8, which corresponds to the calculation section).

$$\mathrm{RL}=(\mathrm{Def}+\mathrm{deg})-(\mathrm{Incr}) = (\mathbf{E_{DEF}}+ \mathbf{E_{DEG}}) - (\mathbf{R_{rec}}+ \mathbf{R_{pla}}) = ((\mathbf{ADef} * \mathbf{FE}) + (\mathbf{ADdeg} * \mathbf{FE}) - (\mathbf{Rrec} * \mathbf{FA}) - (\mathbf{Rpla} * \mathbf{FA}))$$

Where:

RL = Reference Level
$\mathbf{E_{DEF}}$ = Emissions from Deforestation
$\mathbf{E_{DEG}}$ = Emissions from degradation
$\mathbf{R_{rec}}$ = Removals from forest degradation recovery
$\mathbf{R_{pla}}$ = Removals due to increased carbon through forest plantations
AD = Activity data for conversion of forest lands to other lands (Deforestation), permanent forest lands with forest cover loss (Degradation), and degraded permanent forest lands that increase their forest cover and establishment of forest plantations (Increases).
FE = Emission factors for deforestation and degradation and absorption factors for carbon increases in forest biomass.
FA = Emission factors for absorption for carbon increases in forest biomass.

To determine the emissions of the reference level, the first step is to calculate the information from the activity data and then make the estimate in tons of CO_2 equivalent.

Below you will find the links to the files to estimate the activity data, as well as the emissions and removals of the reference level.

- File containing the estimates of emissions and removals for each of the REDD+ activities:
- File that contains the information of the point grid with its categories of land use:

Guatemala does not consider the annual loss of biomass due to forest removal (harvesting), the collection of fuel wood and other losses caused by disturbances, storms, insects and forest and diseases. The estimates for each activity are made separately with specific assumptions based on the information available, and their methods of obtaining activity data and their emission and absorption factors.

5.2.4 Activity data and emission factors used for calculating the average Annual historical emissions over the Reference Period

Activity data

Parameter:	Deforestation
Description:	Forest land converted to non-forest uses The following equations were used to calculate this parameter: Activity data: Equation 3 Additionally, to convert the data to emissions we used equation 8.
Data unit:	Hectares
Source of data and description of measurement/calculation methods and procedures applied:	To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

The interpreters who performed the interpretation and after labeling the 11,369 and labeling the change, a filter was made to identify those points that were deforestation within the program area. A total of 27 points were identified within the program area, to then use the equation found in section 2.1.1 to obtain the data on hectares of deforestation. The table 68 of applied values shows the main transitions caused by deforestation.

The total number of hectares deforested at the reference level was 23,944.28 ha.

The information corresponding to the activity data can be found in the excel file called "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir". In the tab called “AreaExterna”

In the NR Program tab and column E of the deforestation section (Rows 7-9) is the information corresponding to the activity data of the reference level. The information in this column is not divided into the years corresponding to the reference level.

Value applied

For deforestation, the land representation categories being used are those according to the IPCC.

Table 67. Deforestation in the reference level

Classification	(Ha)
Forest I to cropland	957.77
Forest I to grasslands	23,944.28
Forest I to other lands	957.77

QA/QC procedures applied:

A review of the non-logical changes was made and the information corresponding to the land cover that did not match was updated.

For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.

Uncertainty associated with this parameter:

Table 68. Uncertainties for deforestation in the monitoring period

Classification	Deforestation
Median	2,440,861
Average	2,582,319
Deviation	1,603,825,524,163
CI – lower limit	985,818
CI – upper limit	4,499,796
%	72

Any comment:

To access the documents and calculations related to this activity, consult the following link:

Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

	Calculation of hectares and emissions/absorptions https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

5.2.5 Calculation of the average annual historical emissions over the Reference Period

Accreditation period year *t*	**Annual average of historical emissions derived from deforestation during the Reference Period (tCO_{2eq}/year)**	**If applicable, annual average of historic emissions from forest degradation during the Reference Period (tCO_{2eq}/year)**	**If applicable, annual average of historical removals by sinks during the Reference Period (tCO_{2eq}/year)**	**Adjustment, if applicable (tCO_{2eq}/year)**	**Reference level (tCO_{2eq}/year)**
2020	**1,096,058.92**				**1,096,058.92**
2021	**1,096,058.92**				**1,096,058.92**
2022	**1,096,058.92**				**1,096,058.92**
2023	**1,096,058.92**				**1,096,058.92**
2024	**1,096,058.92**				**1,096,058.92**

5.3 Estimated reference level

ER Program Reference level

Crediting Period year	Average annual historical emissions from deforestation over the Reference Period (tCO2-e/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO2-e/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO2-e/yr)	Adjustment, if applicable (tCO2-e/yr)	Reference level (tCO2-e/yr)
2020	1,096,058.92				1,096,058.92
2021	1,096,058.92				1,096,058.92
2022	1,096,058.92				1,096,058.92
2023	1,096,058.92				1,096,058.92
2024	1,096,058.92				1,096,058.92

5.3 MONITORING AND REPORTING PERIOD

5.3.1 Measurement, monitoring and reporting approach

Line Diagram

The following diagram (Figure 4) shows the different components of the MRV System of the emission reduction program under the FCPF, where the main activities related to the generation of activity data, the estimation of emission/removal factors and the calculation of emissions and removals to obtain the emission reductions for the year of interest are presented. This line diagram is complemented by Figure 3, which details those responsible for the preparation of carbon accounting, safeguards, benefit sharing plan and non-carbon variables. The line diagram shows the step by step (seven steps in total) of each of the steps that are needed to have as a final result the emission reductions for the monitoring period.

For the process of calculating emissions reductions, the line diagram is intended to show the different processes from the generation of activity data, the allocation of carbon content, obtaining the emission and removal factors to obtain the emissions and removals of the reference level and the first monitoring. These processes are in charge of the head of the Geographic Information Systems unit of INAB with technical support from UVG.

Each step of the line diagram is described below:

- Step 1 Simple Base Area Estimation:

Consists of the use of the collect earth tool which allows us to use the high resolution images available in the Google Earth catalog. The tool also has external support to consult Planet, Sentinel and Landsat images, as well as to consult vegetation indexes. The document can be accessed:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

- Step 2 Visual interpretation of the CEP form:

In this step the visual interpretation of the 11,369 plots that are randomly distributed in Guatemala is performed. The collect earth form allows to establish the coverage and use for the current year, as well as to establish the

coverage of the previous year. It also assigns whether the plot is a permanence or change in use, in addition to recording the date of the images used. The database is then exported and transformed from a comma-separated format to an Excel file. The form can be accessed through this link:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

CEO Project: https://drive.google.com/drive/folders/1IhxjFz5gPGKg-qCbXXBwU9cDOSnQ0E5m?usp=drive_link

- Intermediate step Prepare emission factors:

In this step we proceed to assign to each of the plots in Guatemala, the forest content stratum to the plots this with the objective of identifying the plots that had a change of use and to know the carbon content prior to deforestation or degradation.

The carbon layer map can be accessed through this link:
https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link
(Open with ArcGis)

The methodological protocol document can be accessed through this link:
https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link

Step 3 Area estimation:
In this stage we proceed to calculate the hectares for each of the REDD+ activities that Guatemala reports, which are deforestation, degradation, carbon increments through the recovery of degradation and forest plantations. To estimate the area, the file "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" is used, and the data is found in column D for the reference level as for the first monitoring.

The document can be accessed through this link:
https://drive.google.com/drive/folders/10Xbascvg4OyHNl5mHQKIkyof8mGJIWmV?usp=drive_link

- Step 4 Allocation of emission factors:

In this step the process that is done is to identify the transitions of all conversions that pertain to deforestation to identify which land use it is and thereby allocate the carbon contents pre and post deforestation.
In the case of degradation and recovery from degradation, the carbon stratum is identified in order to deduct 50% of the carbon initially held. To identify the emission factors from both forest and non-forest carbon content, use the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" and consult the column P, both for the reference level and the first monitoring.

The excel file can be consulted at the following link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

- Step 5: Calculation of CO2/year per activity

In this step the process is to make the sum of the transitions associated with deforestation, degradation, increases in carbon by recovery of degradation and forest plantations. After the summation, the division is made in the corresponding years between the monitoring period or the reference level period. To identify the emissions from the identified activities, the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" can be used and the column AB can be consulted, both for the reference level and the first monitoring.

The excel file can be consulted at the following link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

- Step 6 Calculation of emissions/removals:

The next step is to obtain the net emissions of the reference level period as the first monitoring period. To perform this calculation, the emissions from deforestation and degradation are added to the sum of the removals from carbon enhancements from restoration of degradation and forest plantations. This operation gives the net emissions, which can be positive, indicating emissions, and negative, indicating removals. To identify the emissions from the identified REDD+ activities, the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" can be used and consult the Summary tab, both for the reference level (Column C) and the first monitoring (Column D).

The excel file can be consulted at the following link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

- Step 7 Emission reduction calculation:

This step is performed using the net emissions of the reference level period and subtracts them from the net emissions of the monitoring period to obtain the emission reductions. To identify the reductions from the identified REDD+ activities, use the excel sheet "Estimacion_ Emisiones_Guatemala_NRF_MR_15Junio2022_subir" and consult the Summary tab, and check column E.

The excel file can be consulted at the following link:
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

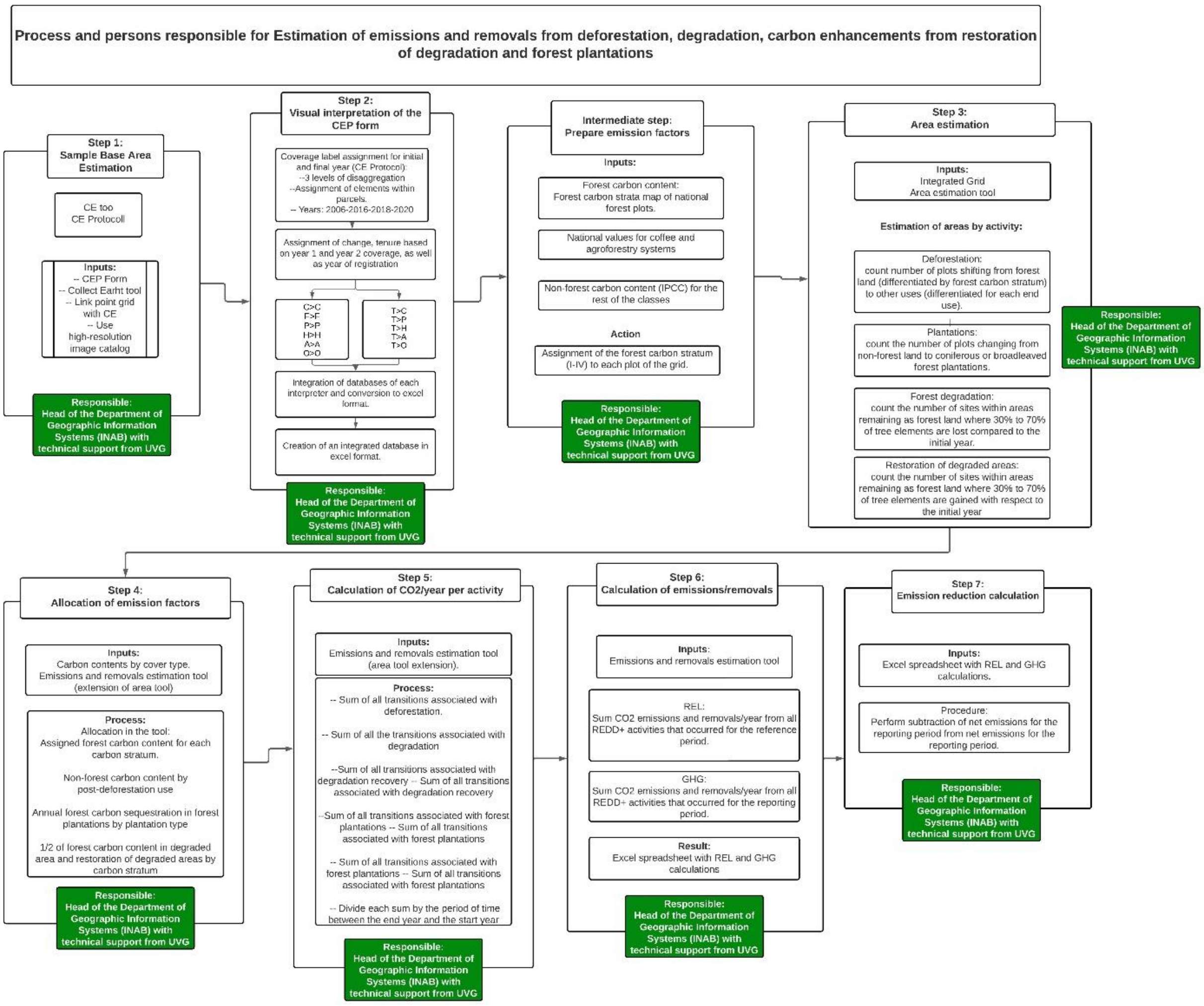

Figure 11. Components for calculating the program's emission reductions.

Calculation

Emission reduction (ER)

$$ER_{ERP}=RL_T-GHG_T \qquad \text{Equation 1}$$

Where:

ER_{ERP}	=	Emission Reductions under the ER Program in year t ($tCO_2e*year^{-1}$)
RL_T	=	Gross emissions of the RL from deforestation over the Reference Period ($tCO_2e*year^{-1}$). Net annual average emissions of the RL due to deforestation and degradation and the absorptions due to the increases in carbon during the reference period(($tCO_2e*year^{-1}$) This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.
GHG_T	=	Monitored gross emissions from deforestation at year t ($tCO_2e*year^{-1}$) Annual net emissions from deforestation and degradation and the absorptions due to increase in carbon in the reporting period ($tCO_2e*year^{-1}$)
T		Number of years during the monitoring period; dimensionless

4. Reference Level (RL)

The RL estimation may be found is provided below. RL was defined as the net annual average historical emissions. Annual emissions or absorptions were estimated for all land transitions by REDD+ activity, and then adding the results for all selected REDD+ activities for each year.

The REDD+ activities that are included in the reference level for Guatemala are:

- Emissions from deforestation and forest degradation.
- Absorptions from increases in forest stock that may be due to recovery of forest degradation and forest plantations.

Equation 2:

$$\mathbf{RL=(Def+deg)-(Incr) = (E_{DEF}+ E_{DEG}) - (R_{rec}+ R_{pla}) = AD * FE/FA}$$

Where:

RL = Reference Level
$\mathbf{E_{DEF}}$ = Emissions from Deforestation
$\mathbf{E_{DEG}}$ = Emissions from degradation
$\mathbf{R_{rec}}$ = Removals from forest degradation recovery
$\mathbf{R_{pla}}$ = Removals due to increased carbon through forest plantations
AD = Activity data for conversion of forest lands to other lands (Deforestation), permanent forest lands with forest cover loss (Degradation), and degraded permanent forest lands that increase their forest cover and establishment of forest plantations (Increases).
FE/FA = Emission factors for deforestation and degradation and absorption factors for carbon increases in forest biomass.

To determine the emissions of the reference level, the first step is to calculate the information from the activity data and then make the estimate in tons of CO_2 equivalent.

Below you will find the links to the files to estimate the activity data, as well as the emissions and removals of the reference level.

- File containing the estimates of emissions and removals for each of the REDD+ activities:
- File that contains the information of the point grid with its categories of land use:

4.1. Reference level activity data

4.1.1. Activity Data of deforestation

To determine the activity data, a random mesh was used consisting of 11,369 plots for the entire country and 10,414 plots for the program area. Each plot has a total of 25 elements and the use is determined by the coverage that predominates.

Equation 3:

$$AD_{def}=\left(\frac{N_{def}}{N_{Total}}\right)*T$$

Where:

AD_{def} = Data derived from deforestation
N_{def} = Number of plots that were interpreted as deforestation in the period studied

N_{Total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

4.2. Reference level emission and removal data

4.2.1. Emissions from Deforestation

Equation 8:

$$\text{Edef} = \sum_{\mathbf{j,i}} \left(\left(\text{C}_{\text{for}} - \text{C}_{\text{nofor}}\right) \text{x}\ \frac{44}{12} \times \text{A(j, i)} \right) / RP$$

Where:

Edef = Emissions caused by deforestation (tCO2 per year)

$\underline{A}_{(j,i)RP}$ = Area from activity data that has been converted from forest type j to non-forest type i during the Reference Period, in hectares per year. In this case, Guatemala, the forests have a division based on four carbon strata:

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

Ten types of non-forest land are considered:

- Cropland (C): What are annual crops, African palm, rubber and coffee. What are annual crops, African palm, rubber and coffee.
- Agroforestry systems such as shade-grown coffee was separated.
- Grassland (P);
- Wetland (A);
- Settlement (U); and
- Other lands (O).

$\underline{C_{for}}$ = Total forest carbon content of each ~~forest carbon content~~ strata j before conversion/transition, in tons of carbon per ha.

$\underline{C_{nofor}}$ = Total non forest carbon content of each non-forest land use i after conversion, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the reference period

The conversions identified for the reference level for Guatemala are the following:

Forest to croplands
- Forest I to cropland lands

Forest to grasslands
- Forest I to grasslands

Forest to other lands
- Forest I to other lands

The following tables show the forest carbon content as well as the content of other non-forest land uses. The origin of each of the values is shown in more detail in Chapter 3 and the respective sections of the report (Annex 4 and 5).

Forest carbon content

Stratum	Forest carbon content -Cfor- (Ton/ha)
Forest I	122.06

Non-forest carbon content

Non forest land Use	Non forest carbon content -Nofor- (Ton/ha)
Croplands (all classes not specified) and grasslands	4.7
Grasslands	6.73
Other lands	0

5. Reporting period (GHG)

Net emissions during the monitoring period in the accounting area are estimated by subtracting carbon emissions and carbon removals.

Equation 12:

$$\mathbf{GHG=(Def+deg)-(Incr) = (E_{DEF}+E_{DEG}) - (R_{rec}+R_{pla}) = ((ADef * FE) + (ADdeg * FE) - (Rrec * FA) - (Rpla * FA))}$$

Where:

GHG = Reporting period
$\mathbf{E_{DEF}}$ = Emissions from Deforestation
$\mathbf{E_{DEG}}$ = Emissions from degradation
$\mathbf{R_{rec}}$ = Removals from forest degradation recovery
$\mathbf{R_{pla}}$ = Removals due to increased carbon through forest plantations
AD = Activity data for conversion of forest lands to other lands (Deforestation), permanent forest lands with forest cover loss (Degradation), other lands that become forest lands and degraded permanent forest lands that increase their forest cover and establishment of forest plantations (Increases).
FE/FA = Emission factors for deforestation and degradation
FA = Absorption factors for carbon increases in forest biomass.

The first step to calculate the net emissions of the monitoring period is the calculation of the activity data.

Activity data of the monitoring period

5.1. Activity Data of deforestation

To determine the activity data, a random mesh was used consisting of 11,369 plots for the entire country and 10,414 plots for the program area. Each plot has a total of 25 elements and the use is determined by the coverage that predominates.

Equation 13:

$$AD_{def}=\left(\frac{N_{def}}{N_{Total}}\right)*T$$

Where:

AD_{def} = Data derived from deforestation
N_{def} = Number of plots that were interpreted as deforestation in the period studied
N_{Total} = Total number of parcels found in the program area
T = Surface area of the program expressed in hectares

5.2. Monitoring period emission and removal data

Equation 18:

5.2.1. Emissions from Deforestation

$$\mathrm{Edef} = \sum_{\mathbf{j,i}} ((\mathrm{C_{for}} - \mathrm{C_{nofor}})\ \mathrm{x}\ \frac{44}{12} \times \mathrm{A(j,i)} \quad)/RP$$

Where:

Edef = Emissions caused by deforestation (tCO2 per year)

$\underline{A}_{(j,i)RP}$ = Area from activity data that has been converted from forest type j to non-forest type i during the Reference Period, in hectares per year. In this case, Guatemala, the forests have a division based on four carbon strata:

- Stratum I
- Stratum II
- Stratum III
- Stratum IV

Ten types of non-forest land are considered:

- Cropland (C): What are annual crops, African palm, rubber and coffee. What are annual crops, African palm, rubber and coffee.
- Agroforestry systems such as shade-grown coffee was separated.
- Grassland (P);
- Wetland (A);
- Settlement (U); and
- Other lands (O).

$\underline{C_{for}}$ = Total forest carbon content of each strata j before conversion/transition, in tons of carbon per ha.

$\underline{C_{nofor}}$ = Total non forest carbon content of each non-forest land use i after conversion, in tons of carbon per ha.

44/12 = Conversion of C to CO_2

RP = Years consisting of the monitoring period

Forest to grasslands

- Forest I to grasslands

Forest carbon content

Stratum	Forest carbon content (Ton/ha)
Forest I	122.06

Non-forest carbon content

Non forest land Use	Non forest carbon content (Ton/ha)
Grasslands	6.73

5.1 Data and parameters

Fixed Data and Parameters

Parameter:	Forest carbon content (Cfor)
Description:	Forest carbon content of four carbon strata before conversion to non-forest land Used in the equations: 8,18
Data unit:	Ton of carbon per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The information generated in the carbon strata map of Guatemala was used to establish biomass above and below ground for forest information. To obtain the carbon content, a study was carried out in which a total of 2,036 forest plots were analyzed, which was prepared by the National Council of Protected Areas with the support of GIMBUT. For more details and explanation of how the value was obtained for the four strata of forest carbon in Guatemala you can consult the report that was made, which is in the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link To obtain greater clarity on how the forest carbon content in Guatemala was constructed, the documents, databases and spatial data have been placed in the section of any comments. The most significant pool includes above-ground biomass carbon from trees greater than 10 cm in diameter (Trees greater than 10 cm DBH[37] are included, because for Guatemala it is the definition of a tree). measured at 1.3 m (DBH). The data of this pool is modeled in the carbon strata map at the national level, which was prepared from 2,306 plots of forest inventories, from different projects, which were systematized, refined, standardized, and analyzed to obtain the value of biomass for each individual greater than 10 cm DBH[38]. General allometric equations were applied, differentiating between broadleaf forests in Petén, coniferous forests, broadleaf forests and mangrove forests. In the latter, three species-specific equations were used. The factor 0.47 was used to convert biomass to carbon and the result per hectare was standardized by dividing the result by the plot size. The second pool, which is related to the previous one, includes below-ground biomass (roots). To estimate below-ground biomass, an above-ground biomass ratio equation was used for all plots (Mokany, Raison & Prokushkin 2006), except for the Mangrove Forest plots, where an equation was used (Komiyama et al. 2008). The following (see Table 5) shows the equations used to calculate the biomass above and below ground for the Petén, conifers, broadleaves and three mangrove species forests, which take into

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[37] For Guatemala, the following definition for a tree is used:
Woody plant with a defined stem and crown with secondary growth that, when mature, reaches a minimum height of 5 meters and a minimum diameter of 10 cm. Bamboos and palms are excluded.

consideration the relationship in function of the proportion of aerial biomass for the below-ground biomass.

Table 69. Allometric equations used.

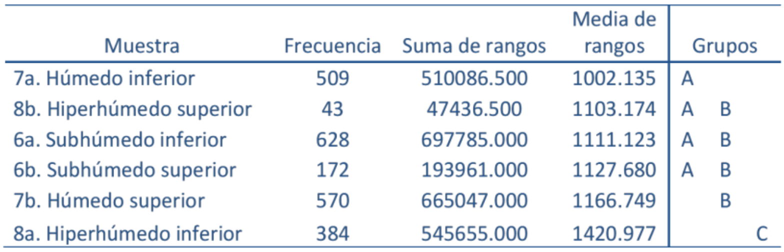
Species/Region	Equation	Source	r2	N	Dmax
Rhizophora mangle L.	0.178*DBH^2.47	Imbert and Rollet	0.98	17	Unknown
Laguncularia racemosa (L.) Gaertn.f.	0.1023*DBH^2.50	Fromard et al.	0.97	70	10
Avicennia germinans (L.) L.	0.14*DBH^2.4	Fromard et al.	0.97	25-45	42.4
Conocarpus erectus L.	0.1023*DBH^2.50	Fromard et al.			
Petén	10^ (-4.09992+(2.57782*LOG10(DBH))) *1000	Arreaga 2002	95	139	130
Broadleaf	0.13647 * DBH^2.38351	UVG 2015	0.939	100	79.9
Conifers	0.15991 * DBH^2.32764	UVG2015	0.966	80	82

With the biomass data for each individual, the conversion of tons of biomass to carbon is made, multiplying by the fraction of 0.47 and the value for one hectare is extrapolated, according to the size of each plot. The values are added for each of the plots, and results in a standardized value of tons of carbon per ha in each of them.

Each plot has geographic location data, and these were stratified bioclimatically, as an indirect measure of primary productivity, based on the ombrothermal indices generated for Guatemala, which were constructed with data obtained from the World Clim digital page, using the monthly precipitation and temperature averages. This climatic classification has been widely used in Guatemala as a basis for regional planning and for the integration of other variables of interest to forest services or biological conservation (CONAP, 2015).

The plots with their carbon content were located in 6 ombric horizons, and data (the carbon content data of the analyzed plots) distribution tests were carried out for each of them, finding that none presented normality in the data distributions. Therefore, to carry out the stratification according to the ombric horizons, a comparison test of k samples (Kruskal-Wallis) was carried out, where statistically differentiated groups were detected as shown below (See Table 6).

Table 70. Grouping categories according to climatic regime.



Muestra	Frecuencia	Suma de rangos	Media de rangos	Grupos		
7a. Húmedo inferior	509	510086.500	1002.135	A		
8b. Hiperhúmedo superior	43	47436.500	1103.174	A	B	
6a. Subhúmedo inferior	628	697785.000	1111.123	A	B	
6b. Subhúmedo superior	172	193961.000	1127.680	A	B	
7b. Húmedo superior	570	665047.000	1166.749		B	
8a. Hiperhúmedo inferior	384	545655.000	1420.977			C

As shown below, from the statistical grouping, four strata were determined at the national level according to the amount of carbon and the zones of ombric horizons (See Table 7). The groups that are observed in table 8, indicate those ombric indices that are statistically related to each other. That is why the result is four groups.

Table 71. Groups in which climatic regimes are classified.

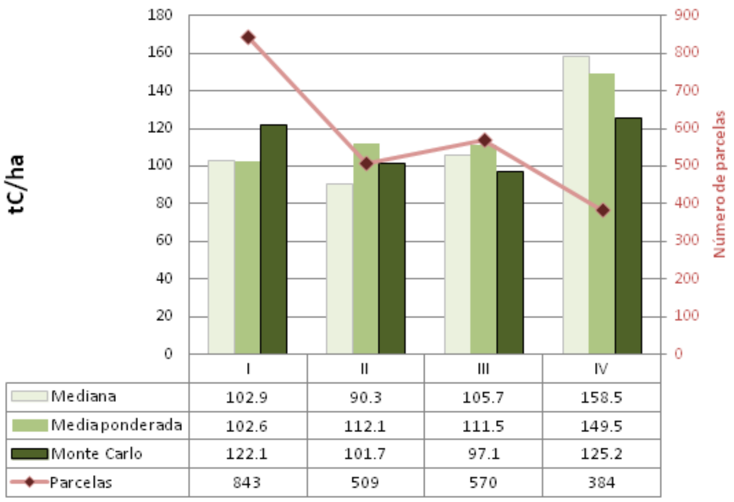
Ombric Horizon	Statistical grouping			Final Group
6a. Subhumid – Low	A	B		I
6b. Subhumid – High	A	B		I
7a. Humid – Low	A			II
7b. Humid – High		B		III
8a. Hyper Humid - Low			C	IV
8b. Hyper Humid - High	A	B		I

With these data, the values were assigned to those areas whose ombric horizon did not have enough plots to be represented (e.g. Dry type), leaving the final stratification as detailed in Table 8, with which the national coverage is achieved.

Table 72. Strata assigned to horizons with insufficient values.

Stratum	Ombric Type	Ombric Horizon
I	4. Semi-Arid	4b. Semi-Arid – High
	5. Dry	5a. Dry – Low
	5. Dry	5b. Dry – High
	6. Sub-Humid	6a. Sub-Humid Low
	6. Sub-Humid	6b. Sub-Humid High
II	7. Humid	7a. Humid – Low
III	7. Humid	7b. Humid - High
IV	8. Hyper-Humid	8a. Hyper-Humid - Low
I	8. Hyper-Humid	8b. Hyper-Humid - High
	9. Ulta Hyper-Humid	9. Ulta Hyper-Humid

In order to have more consistent data in the estimation of tons of carbon per hectare and per stratum, descriptive statistics were made for each group and the resulting carbon content ranges were compared. Due to the great variability of the data according to the size of the plots and sampling designs, calculations of carbon density were made with the median and the weighted mean was also calculated for the four strata according to the proposal of Thomas and Rennie, 1987, who define that variance is a good estimator of the mean. Due to the variability of sampling designs for different purposes, data distribution (non-normal) and plot sizes, the Monte Carlo method was used to estimate carbon in the cartographic model (carbon map) because it weights directly the size of the plot and identifies the probability density function (PDF) of the data by plot size and by stratum through goodness-of-fit tests (Gómez Xutuc, 2017). Once the PDFs have been identified, it performs simulations of the carbon content per hectare, obtaining a better estimator from their Probability Density Functions (PDFs) (Figure 6). Thus, 10,000 simulations were run, truncating distributions according to the minimum and maximum of each data (tC/ha) by plot size and by stratum, respectively. The median was used for the analysis, since these are data that do not present a normal distribution.



	I	II	III	IV
Mediana	102.9	90.3	105.7	158.5
Mediaponderada	102.6	112.1	111.5	149.5
Monte Carlo	122.1	101.7	97.1	125.2
Parcelas	843	509	570	384

Figure 12. Estimated values for the carbon map.

Value applied:

The final values of forest biomass above and below ground were as follows.

Table 73. Carbon values obtained for each stratum.

Strata	Median	Typical Deviation
I	122.06	0.187
II	101.73	0.553
III	97.11	0.459
IV	125.19	0.602

QA/QC procedures applied

Review and evaluation of atypical data for its depuration.

A bounded equation was made based on maximum and minimum carbon values. Poorly located plots that did not have a correct georeferencing location were purged located plots that did not have a correct georeferencing location were purged.

Additional analysis was done to check the accuracy of the map against the plots of the project inventories. Since the country also submitted a reference level to the United Nations Convention on Climate Change, we proceeded to review whether the correspondence of the map's carbon layers was in line with reality. Therefore, INAB proceeded to perform an analysis to evaluate the quality of the carbon layers map, which can be found in the folder in this link:

https://drive.google.com/drive/folders/1C6k1IMQkxKnS9_EEiCnRUXdH42fvU8-P?usp=share_link

Uncertainty associated with this parameter:

Table 74. Uncertainty of the carbon strata after applying the Monte Carlo method.

Strata	Median	Uncertainty (%)
I	145.34	22.44
II	101.57	97.88
III	109.93	77.29
IV	153.70	60.80

	The values found in table 10 are the result of the modeling for the carbon strata for the calculation of the uncertainty of the emission reduction.
Any comment:	To access the documents and calculations related to this activity, consult the following link: Methodological report: https://drive.google.com/file/d/1JSqjLfcdaOWi2uM_6PXoVoFdGkGqZ3ID/view?usp=drive_link Database to build the carbon strata of Guatemala: https://docs.google.com/spreadsheets/d/1K7NZf9F5-ez1iYOvNYZmDcmrnmwYEa8o/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true Shapefile: https://drive.google.com/file/d/1J_RajMbPtgfl6XgJMXfyKaI1k_A1v93f/view?usp=drive_link

<table>
<tr><td>Parameter:</td><td>Non forest carbon content (Cnofor)</td></tr>
<tr><td>Description:</td><td>Non-forest carbon content after conversion of forest land to non-forest land
Used in the equations: 9 and 19</td></tr>
<tr><td>Data unit:</td><td>Tons of carbon/ha</td></tr>
<tr><td>Source of data or description of the method for developing the data, including the spatial level of the data (local, regional, national or international):</td><td>In order to have an estimation of the emissions that is closer to reality and to assign a biomass existence value after deforestation, depending on the type of activity that is carried out, in addition to the data obtained for the country for agroforestry systems, the general default values were used for land converted to cropland during the year following conversion, from the 2006 IPCC Guidelines for Wet Tropical Annual and Perennial Crops and their associated error range found in IPCC Table 5.9 (2006). The values for these other non-forest use categories were used as described below (See Table 11):
Table 75. Carbon in biomass after conversion due to deforestation.
<table>
<tr><th>Other land uses</th><th>Ton Carbon/ha</th><th>Range of error and/or uncertainty</th><th>Source</th></tr>
<tr><td>Croplands (all classes not specified) and grasslands</td><td>4.7</td><td>±75%</td><td>IPCC 2019 (Volume 4,Table 5.9, chapter 5 Croplands, annual croplands)</td></tr>
<tr><td>Croplands-Coffee (intensive)</td><td>2.65</td><td>±75%</td><td>Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in</td></tr>
</table>
</td></tr>
</table>

Grasslands	6.73	±75%	IPCC 2006 (Table 6.4, chapter 6 Grasslands)
Croplands-African Palm	2.4	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)[39]
Croplands-Rubber	3	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Agroforestry systems (shaded coffee)	20.1	1.34%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in Guatemala. PROMECAFE
Settlements	0.00	N/A	IPCC 2006
Wetlands	0.00	N/A	IPCC 2006
Other lands	0.00	N/A	IPCC 2006

Note: Since there are national values, it is suggested to leave this table to have all the non-forest carbon content values so that it is easier to replicate the Reference Levels and the Monitoring Period results in the process of rebuilding the estimation of reductions.

Value applied:

Other land uses	Ton Carbon/ha	Range of error and/or uncertainty	Source
Croplands (all classes not specified) and grasslands	4.7	±75%	IPCC 2019 (Table 5.9, chapter 5 Croplands, annual croplands)
Croplands-Coffee (intensive)	2.65	±75%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in
Grasslands	6.73	±75%	IPCC 2006 (Table 6.4, chapter 6 Grasslands)

Croplands-African Palm	2.4	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Croplands-Rubber	3	±75%	IPCC 2006 (Table 5.3, chapter 5 Croplands, Very Wet Tropical Perennial Croplands)
Agroforestry systems (shaded coffee)	20.1	1.34%	Alvarado J, López D, Medina B. Estimated quantification of carbon dioxide fixed by the coffee agroecosystem in
Settlements	0.00	N/A	IPCC 2006
Wetlands	0.00	N/A	IPCC 2006
Other lands	0.00	N/A	IPCC 2006

Note: Since there are national values, it is suggested to leave this table to have all the non-forest carbon content values so that it is easier to replicate the Reference Levels and the Monitoring Period results in the process of rebuilding the estimation of reductions.

QA/QC procedures applied

Does not apply because they are default values taken from the IPCC Guidelines.

Uncertainty associated with this parameter:

Table 76. Uncertainty of carbon content in non-forest land

Classification	Agriculture	Coffee	Palm	Rubber	Agroforestry	Grasslands
Mean	4.7	2.6	2.4	3.0	20.3	6.7
Average	4.7	2.7	2.4	3.0	20.2	6.8
Deviation	3.1	0.3	0.2	0.0	361.6	55.8
CI – lower limit	1.22	1.64	1.44	2.63	-16.72	-7.78
CI – upper limit	8.15	3.70	3.35	3.38	57.12	21.51
%	73.43	38.93	39.83	12.58	181.82	218.33

Any comment:

To access the documents and calculations related to this activity, consult the following link:

Chapter Croplands for Croplands:
https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch05_Cropland.pdf

Chapter Croplands for African Palm and Rubber:
https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf

Chapter Grasslands

	https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf Data for intensive coffee and Agroforestry systems (shaded coffee): https://drive.google.com/file/d/1kXI5Pxr_iUJOffJJTfVBTjF2iWihs3tq/view?usp=drive_link https://docs.google.com/presentation/d/1JjSan9z5CYySzZuhCwRWxW9c1tR2nyww/edit?usp=drive_link&ouid=115188584703966598135&rtpof=true&sd=true

Monitored Data and Parameters

<table>
<tr><td>Parameter:</td><td>Deforestation</td></tr>
<tr><td>Description:</td><td>Forest land converted to non-forest uses
The following equations were used to calculate this parameter:
Activity data: Equation 13
Additionally, to convert the data to emissions we used equation 1<i>8</i>.</td></tr>
<tr><td>Data unit:</td><td>Hectares</td></tr>
<tr><td>Value monitored during this Monitoring/Reporting Period:</td><td><table><tr><th>Category</th><th>Ha</th></tr><tr><td>Forest I to grasslands</td><td>3,831.08</td></tr></table></td></tr>
<tr><td>Source of data and description of measurement/calculation methods and procedures applied:</td><td>To generate the activity data for this parameter, Collect Earth was used as a platform for the collection of land use information for the years of interest, which allows us to identify the permanence and changes that occurred in these years. For the identification of these land uses, Guatemala uses the IPPC classification to establish the land use of the parcel being observed. To use the Collect Earth form, Guatemala has a methodological protocol for its use, which can be consulted at the following link: https://drive.google.com/drive/folders/1uAYrJ4GdtwBOeVxW3fVWufGJnj_TRY7f?usp=drive_link
The total number of interpreters who carried out the analysis of the images were three specialists: Ulises Armas, Claudia Saput and Melany Ramirez.
For the identification of deforestation, plots were identified in which, during the 2018-2020 period, they lost their entire forest cover or suffered a degradation process greater than 70% loss of the elements corresponding to trees.
After interpreting the 11,369 and labeling the change, a filter was made to identify those points that were deforestation. 47 points were identified within the program area, to then use the equation found in section 3.1.1 to obtain the data on hectares of deforestation. For monitoring, a total of 47 deforestation points were identified, which is equivalent to a total of 42,068.05 ha.
After the identification of the deforested plots, the forest stratum was identified for each of the plots and the carbon content was assigned. Then, the non-forest cover to which the plot passed was identified and the carbon content for this use was assigned.</td></tr>
</table>

<table>
<tr><td></td><td>The information corresponding to the activity data can be found in the excel file called https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link

In the tab “AreaExterna” column E, in the section corresponding to Deforestation is the information corresponding to the activity data for the reporting period. The information in this column is not divided into the year’s corresponding to the monitoring.</td></tr>
<tr><td>QA/QC procedures applied:</td><td>A review of the non-logical changes was made and the information corresponding to the land cover that did not match was updated.

For quality control, the criterion of using 5% of the sample corresponding to the total deforestation points was used, with a 95% confidence interval and an expected 5% error.</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>Table 77. Uncertainties for deforestation in the monitoring period
<table>
<tr><th>Classification</th><th>Deforestation</th></tr>
<tr><td>Median</td><td>44,951.1</td></tr>
<tr><td>Average</td><td>45,032.8</td></tr>
<tr><td>Deviation</td><td>42,905,355.4</td></tr>
<tr><td>CI – lower limit</td><td>32,024.6</td></tr>
<tr><td>CI – upper limit</td><td>58,084.9</td></tr>
<tr><td>%</td><td>29.0</td></tr>
</table></td></tr>
<tr><td>Any comment:</td><td>To access the documents and calculations related to this activity, consult the following link:
Activity data:
https://drive.google.com/drive/folders/1IkdB23TshF34qD3f4lCW7A8Y0Lzzc6Tq?usp=drive_link

Calculation of hectares and emissions/absorptions
https://drive.google.com/drive/folders/1IeKJfsDIkiep0RFqDg3vH-X2zhI9ZICq?usp=drive_link</td></tr>
</table>

5.4 QUANTIFICATION OF EMISSION REDUCTIONS

5.4.1 Reference level for the Monitoring / Reporting Period covered in this report

Year of Monitoring/Reporting period *t*	**Average annual historical emissions from deforestation over the Reference Period (tCO2-e/yr)**	**If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO2-**	**If applicable, average annual historical removals by sinks over the Reference Period (tCO2-e/yr)**	**Adjustment, if applicable (tCO2-e/yr)**	**Reference level (tCO2-e/yr)**
2020	1,096,058.92	-	-	-	1,096,058.92
Total	**1,096,058.92**	**-**	**-**	**-**	**1,096,058.92**

5.4.2 Estimation of emissions by sources and removals by sinks included

Year of Monitoring/Reporting Period	**Emissions from deforestation (tCO2-e/yr)**	**If applicable, emissions from forest degradation (tCO2-e/yr)***	**If applicable, removals by sinks (tCO2-e/yr)**	**Net emissions and removals (tCO2-e/yr)**
2020	809,616.71	-	-	809,616.71
Total	**809,616.71**	-	-	**809,616.71**

5.4.3 Calculation of emission reductions

Total Reference Level emissions during the Reporting Period (tCO2-e)		**1,096,058.92**
Net emissions and removals under the ER Program during the Reporting Period (tCO2-e)	**2020**	**809,616.71**
Emission Reductions during the Reporting Period (tCO2-e)	**2020**	**286,442.21**

5.5UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

Uncertainty of Reference Level emissions during the Monitoring Period (%)		71.46
Uncertainty of net emissions and removals under the ER Program during the Monitoring Period (%)	**2020**	77.65
Uncertainty of Emission Reductions during the Reporting Period (%)	**2020**	77.65

Document history

Version	Date	Description
1	June 2022	The initial version moved for approval by Carbon Fund Participants during a three-week no-objection period.

Document history

Version	Date	Description
2.4	May 2022	- Page 1 and section 8 have been adjusted to reflect the dentition of Total ERs
2.3	December 2021	- Section 5.2 was adjusted to allow the reporting of the uncertainty estimates for both the reporting period and the crediting period. - Section 8 has been adjusted to clarify that countries can also report ERs jointly and not only in separate calendar years.
2.2	August 2021	- Cross-references have been corrected - Information about the start date of the crediting period has been requested in annex 4.
2.1	November 2020	Aspects on uncertainty analysis were revised based on the guidelines on uncertainty analysis.
2	June 2020	Version approved virtually by Carbon Fund Participants. Changes made: - Update to consider the changes made to the Methodological Framework (Version 3.0) and Buffer Guidelines (Version 2.0) - Update to consider the changes made to the Validation and Verification Guidelines
1	January 2019	The initial version approved by Carbon Fund Participants during a three-week non-objection period.