Forest Carbon Partnership Facility (FCPF)

Carbon Fund

ER Monitoring Report (ER-MR)

ER Program Name and Country:	Dominican Republic
Reporting Period covered in this report:	01-03-2021 to 31-12-2021
Number of FCPF ERs:	1,278,592
Quantity of ERs allocated to the Uncertainty Buffer:	282,042
Quantity of ERs to allocated to the Reversal Buffer:	239,736
Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:	79,911
Date of Submission:	30-05-2022
Version	2

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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

Progress on the actions and interventions under the ER Program (including key dates and milestones);

The Dominican Republic (DR) is simultaneously going through a REDD+ Readiness Preparation process and implementing the ER Program. As part of the REDD+ Readiness Preparation process, the Government of DR (GoDR) is developed a National REDD+ Strategy (ENREDD+ per its acronym in Spanish). ENREDD+ includes a set of mitigation and adaptation measures that will contribute to reducing deforestation and forest degradation and promote productivity of the forest sector. The ENREDD+ is developed by the Climate Change Directorate of the Ministry of the Environment based on the results of several analytical studies funded by the Forest Carbon Partnership Facility (FCPF) REDD+ Readiness Preparation grant. The REDD+ Program is expected to become the first step towards implementing the ENREDD+. REDD Program activities are based on three strategic pillars comprising 22 strategic actions:

a) Strengthening of the legal and institutional framework and enforcement of the law, for the conservation of natural heritage and the sustainable use of natural resources.
b) Establishing, strengthening, and applying public policies to limit and/or contain the expansion of the agricultural and cattle ranching frontiers and infrastructure into forest areas.
c) Promoting natural resource management models that contribute to sustainable and productive uses, including the growth of local and small and medium forest enterprises, as well as the conservation of forests.

Whereas pillars a) and b) include strategic actions aimed at strengthening the environment favorable to the implementation of REDD+ Program; pillar c) refers to strategic actions and training programs that promote sustainable forest management. More specifically, pillar a) groups activities targeting collaboration with institutions to improve the existing legal frameworks that do not promote the emissions reduction or act as a perverse incentive that expands deforestation. It also aims at establishing the appropriate enforcement mechanisms to counteract deforestation and forest degradation. Activities grouped in pillar b) include establishing areas for sustainable forest management, and the zoning of areas for agricultural and livestock production compatible with forest conservation. Actions grouped in component c) will promote sustainable forest conservation and management, as well as the establishment of sustainable productive systems based on agroforestry and sustainable livestock farming. The first two strategic options or pillars will generate legal and institutional conditions to meet the established reduction goals, while the third includes actions to be carried out in the field through successful plans, programs and projects being developed in the country

REDD+ activities is implemented through various public and private entities including government agencies such as the Ministry of the Environment and the Ministry of Agriculture or the private sector such as San Ramón Foresters Association referred to as Executing Entities (EEs). REDD+ activities are linked to EE plans, projects, and programs. EEs will sign an inter-institutional agreement with the Ministry of the Environment to comply with the conditions stipulated in the REDD+ Program and in this document, following which participating EEs will be registered. EEs identified to date include the following: (a) Vice- Ministries of Forest Resources, Protected Areas and Biodiversity, (b) the Technical Implementing Unit of the Presidency for Agroforestry Development Projects (UTEPDA), (c) the Cocoa Department of the Ministry of Agriculture, (d) Dominican Coffee Institute (INDOCAFÉ), (e) General Livestock Directorate (DIGEGA) / the National Board for Regulation and Development of the Milk Industry (CONALECHE), (f) San Ramón Foresters Association, and (g) the Sustainable Forest Development Association from the Municipality of Restauracion (ASODEFOREST).

During 2021, the Executing Entities presented the contents of the REDD+ program, its importance, benefits, co-benefits and how they can participate to the producers they serve. Due to the COVID19 pandemic in 2021, EEs had difficulties executing their activities, such as technical assistance, delivery of supplies, and delay in producing seedlings in their nurseries. Some EEs made efforts to strengthen their technical support monitoring strategy, such as the Dominican Coffee Institute (INDOCAFE), which is working on registration and monitoring software, and the Ministry of Agriculture, which works on another registration system for livestock and cocoa activities. Despite the difficulties of seedling production, plants were delivered for planting, both for establishing Agroforestry Systems and for forest restoration and reforestation. In this sense, it is worth mentioning the work of the Associations of Silviculturists San Ramón de San José de Las Matas (25 ha of reforestation), the Sustainable Forest Restoration Development, INDOCAFE (this EE established around 33 ha of new hectares and 692 ha of renewed AFS), the Ministry of Agriculture (this Ministry reported seedlings distribution for planting new areas and renewing around 943 hectares of Cocoa AFS) and the Reforestation Program (258 ha of reforestation).

The Vice Ministry of Forestry Resources established 6,399 ha of Forest plantations in 2021. The area planted in the Agroforestry Projects reached 2,918 ha and 2,509,868 trees in 7 sites in the country's southern region. Likewise, 22 natural forest management operational plans were approved for logging 7,513 m3. Also, cutting authorizations were issued for 1,254 hectares of forest plantations (35,534 m3), including 72 plantation certificates with the right to cut granted to these beneficiaries in 591 ha, where 460,321 trees were planted[1].

Finally, the technicians of the Institutions were trained in sustainable or environmentally friendly livestock. Reforestation tasks continued to be carried out, although reduced, on private and public lands, with the local brigades of the Vice Ministry of Forest Resources.

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 ER Program.

Assumptions in the financial plan have not changed. The estimated budget was elaborated based on the predefined components and activities of the National REDD+ Strategy EN-REDD+ predefined by the Government. Activities were classified into two types: (i) Enabling environment activities; and (ii) Direct investment activities. Enabling environment activities (also referred as costs) are classified into 2 types: Institutional, and transaction activities. Enabling activities are expected to be financed with resources from the Environment’s existing programs, budget and other REDD+ cooperation programs.

Direct investment activities on the other hand, also referred as implementation activities, are expected to contribute to carbon emissions reductions and consider working closely with private actors (e.g. individuals or associations) in the implementation of actions that will contribute to the protection of forests, restoration of degraded forest areas and the transformation of agricultural and agroforestry areas.

A budget analysis exercise was used for estimating the cost of the ER-Program. This analysis indicates that $153.9 million USD will be required for the ER-Program and that $166.9 million USD has been identified as potential sources of funding. Thus, preliminary results indicate a positive net balance of $13 million USD in the financing of the Program after receiving ER payments. Activities envisioned in the ER-Program are expected to be complemented with private sector actions that will contribute to the protection/preservation of current forests, restoration of areas, and transformation of agricultural land. This economic analysis estimates that US $ 94,7 million would be required for the implementation of these activities during the first five years (2020-2024) of the Program. For the first 5 years, it is projected that in aggregated terms the benefits will grow up to $104,5 million USD.

This economic analysis will be used to develop a business plan that will include a strategy to engage the private sector. The business plan is intended to be discussed with a roundtable of international cooperation donors that the World Bank office in Dominican Republic put together, as well as with the roundtable of international cooperation that the Ministry of Economy, Planning and Development (MEPyD) has set up. The business plan will aim at attracting: private investors for the three main commodities (livestock, cocoa, coffee), international cooperation donors, and a path towards the use of public revenues to establish climate smart agriculture in selected areas.

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[1] Viceministerio de Recursos Forestales, 2021. Memoria Institucional 2021-Memoria anual Viceministerio de Recursos Forestales.

Table 1-1: Implementation costs and sources of funding of the ER-Program

Total financing Gap Public Sector						
						constant $ thousands 2018
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
Total cost REDD+ Government actions (i)	28,385	34,994	38,454	28,992	23,115	-
Total contributions of the Dominican Republic Government	25,471	31,861	34,361	25,084	19,025	-
Total Income from the sale of Emissions Reductions (ii)	-	-	11,319	-	-	19,816
Total public sources for REDD+ implementation*	25,471	31,861	45,679	25,084	19,025	19,816
Financial gap	-2,914	-3,133	7,226	-3,908	-4,090	19,816
Financial gap – Cumulative (iii)	-2,914	-6,047	1,179	-2,729	-6,819	12,998
* Calculations include ER-Payments						
i.Total cost REDD+ Government Actions in 5 years = US$153,940						
ii.Total income from the sale of ER= US$31,135						
iii.Positive Net Balance in the financing of the program after ER Payments =US$12,998						

1.2 Update on major drivers and lessons learned

The principal direct causal factors of deforestation are commercial livestock farming and the illegal logging of the natural forest, both identified as extremely high priority, followed by commercial and shifting/subsistence agriculture, catalogued as high priority causal factors. The agri-food sector is considered one of country's engines of growth, it includes agricultural, livestock, forestry, and fishing activities. This sector contributed to 5.6 percent of the national GDP in 2017. Slash and burn agriculture, and extensive livestock production practices in upper watersheds have been identified as the main direct activities driving deforestation in recent years.

Degradation and deforestation resulting from poor management and unsustainable use of forest land, could be divided in two: i) Illegal logging, driven by the value of the products (timber, poles, firewood, and charcoal, ii) area involved under the forest management plan, in which sustainable extraction from the forest does not take place. Wildfires, mining, pests and diseases, infrastructure (including urban, road and tourism infrastructure) have also been identified important drivers of deforestation and forest degradation. Weak forest management institutions, the absence of an adequate regulatory framework for the forest sector, transboundary migration pressure and poverty constitute the main underlying drivers of deforestation and degradation.

It is essential to highlight that the displacement risk of deforestation is low. Agricultural activity in the country is primarily pursued by smallholders. The intensive breeding of livestock and agriculture for self-consumption and sale in local markets represent the main livelihood of rural families and they are practices strongly rooted in their traditions. The rural exodus, the slow-down in agricultural development and the growing importance of the remittances in the rural economy have transformed livestock rearing into the dominant land-use. The REDD+ strategy takes account of the establishment, strengthening and application of public policies to limit and/or contain the expansion of the agricultural and livestock frontier in forested areas. It is considered unlikely that these regulations will oblige smallholders to displace their agricultural activities to the neighboring country.

The displacement risk of degradation is also considered low. Even tough Haiti imports a large proportion of the coal production of the Dominican Republic, the country is significantly reducing coal production. The impact caused by the use of forests for coal and firewood production has reduced significantly, due to the incentive for the use of liquefied petroleum gas. There has been a radical change over the last two decades, declining from 1,595,877 75-

pound sacks in 1982 to just 75,000 sacks in 2003. It is estimated that some 265,067 Dominican households (10% of all households) use firewood and coal for food cooking.

Figure 1-1 shows that significant deforestation drivers identified for the Reference Period in the ER Accounting Area have not changed. Croplands and Grasslands are related with the highest deforestation rates. Also, it is essential to highlight that the deforestation rate has increased between 13% and 126% during the monitoring periods (2016-2018 and 2019-2021).

Figure 1-2 shows that emissions from forest degradation have also increased significantly during the monitoring periods (between 253% and 899%). However, forest gain and canopy recovery removals have also increased (Permanent Forest canopy cover recovery -117% and 591%; Reforestation removals 17%-22%). Further analysis will be required to understand this critical change in the carbon flux of permanent forest lands. Finally, a positive balance of emission reductions is obtained when comparing the net emissions with the FREL/FRL for the reporting period (March 1st – December 31st 2021). These ERs are produced because changes in the rate of removals exceeded the changes in the rate of emissions.

Update on the strategy to mitigate and/or minimize potential Displacement.

The strategy to mitigate potential Displacement has not changed. The ER-Program includes the following Strategic Actions aimed at preventing and minimizing possible internal displacement of activities within the country (although not considered displacement of emissions, in accordance with the Methodological Framework).

Intensify agriculture and cattle farming, by setting up AFS (Strategic actions 3.2 and 3.4): Those who incorporate agroforestry systems (AFS) into their production units – rather than experiencing a production drop – will enjoy better agricultural yields in those areas where intensification is appropriate, without having to multiply their production units or move their business. Those areas where ASF are not appropriate may see their forests restored. Farms' remaining woodland areas can be turned into conservation ventures where money is received in exchange for environmental services.

Some players in the agricultural sector have started to modify cultural practices, integrating some level of woodland cover in their production systems in order to intensify production (increase productivity per unit area). Some institutions have also taken measures. The Directorate-General for Cattle Farming is promoting the introduction of trees on cattle farms in order to reduce temperature-related stress and improve pastureland growth. The Ministry of Agriculture, via the Cocoa Department, encourages agricultural systems where cocoa is grown in the shade. Furthermore, INDOCAFE is responsible for fostering agricultural systems where coffee is grown in the shade. In both cases, the aim is to improve nutrient recycling and control erosion, which in turn will lead to a reduction in the need for fertilisers as well as stable or even greater productivity.

Sustainable wood and charcoal production (Strategic actions 3.4 and 3.6): The idea is to guarantee that domestic and foreign demand for charcoal is satisfied, in order to avoid business going elsewhere. As well as strengthening forest protection and monitoring, sustainable management of natural woodland and forest plantations will be promoted in all five frontier communities where charcoal production is unsustainable.

The Dominican Republic has had several successful experiences with sustainable forest management, including: i) the Sabana Clara management project, ii) the La Celestina project, and iii) woodland management the ASODEFOREST. The Vice-ministry for Forest Resources is in charge of the Sabana Clara project. It started operating in 2003. Its objectives include: i) replanting in damaged areas in order to guarantee the sustainable production of water from the Río Artibonito basin, ii) setting up sustainable natural woodland management to foster a model forestry industry, where woodland product yields are maximised. The San Ramón Association of Woodland Farmers is in charge of the La Celestina project. It was set up in the context of an agreement with El Plan Sierra. Operations started in 1983. Its main objectives are the protection, improvement, conservation and restoration of natural woodland and established plantations, via culling operations, thereby making sustainable use of forest resources.

Shifting industrial and tourism development (Strategic actions 3.6, 3.8 y 3.9): Ecosystem restoration plans will be promoted in order to avoid having industrial and tourism-related activities move to other countries. Restoring woodland ecosystems will favour appropriate infrastructure developments (mostly industry and tourism-related) and compliance with environmental norms.

All necessary links will be established between the different restoration initiatives that are currently being implemented and the industrial and tourism-related developments that may have an impact on forest resources. Setting up resource transfers will allow us to restore the affected resource in a cost effective and permanent manner.

Forestry legislation foresees that any woodland thinning implies a duty to replant. Furthermore, where industrial expansion leads to clearing woodland, there is a duty to replant the cleared area. Flood-causing hydroelectric dams, electrical transmission lines, new highways, and new industrial complexes are just some examples. As a result, reforestation of culled areas will occur in previously woodless areas, whilst the net woodland loss should be nil.

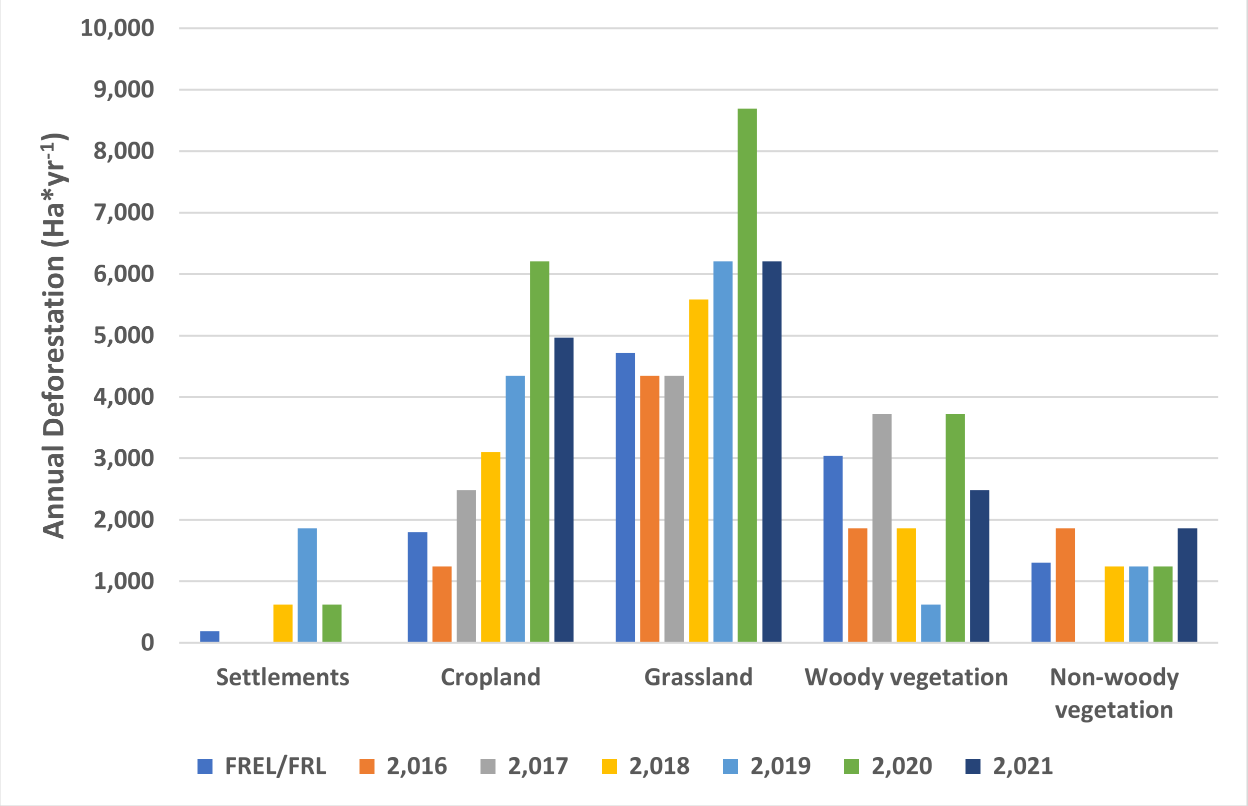

Figure 1-1: Distribution of the deforested area during the monitoring periods 2016-2018 and 2019-2021.

Figure 1-2: Monitoring results of the REDD+ activities included in the carbon accounting of the ER Program during the 2016-2018 and 2019-2021 monitoring periods.

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

2.1 Forest Monitoring System

Organizational structure, responsibilities, and competencies.

The Ministry of Environment and Natural Resources is the designated national authority and focal point for climate change. The organizational structure of the Emission Reduction Monitoring Report (ER-MR) is made up primarily of agencies of the Ministry of Environment: Department of Climate Change, Department of Environmental Information and Natural Resources (DIARENA), Forest Monitoring Unit "FMU", Department of Biodiversity and Wildlife and the Department of Social Participation. Figure 2-1 and Table 2.1 present roles and responsibilities of each of these agencies for collecting, processing, consolidating, and reporting GHG data and information.

Consistency with the National Forest Monitoring System

The institutional procedures and arrangements established for ER-MR will be used as the basis for the design and establishment of the National Forest Monitoring System, which will use the same methodologies; in fact, the MRV system of the ERPD is based on the national forest monitoring system.

Standard Operating Procedures and QA/QC procedures of the Forest Monitoring System:

Land use biomass density estimate: Three sources of data were used to estimate total biomass in each of the land uses and the emission factors in the land-use change categories: a. The National Forest Inventory (**NFI**)[2], b Assessment of Biomass and Carbon Content in Non-Forest Cover in the Dominican Republic" (**ISNB**)[3], and c. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015 (**Technical Correction Inventory**) [4]. For each of these biomass estimation plot surveys, SOPs were prepared.

- **NFI**: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[5] and QA/QC[6] procedures to reduce non-sampling errors. Since the beginning of the planning phase, courses on basic forest inventory techniques were given to 68 forestry technicians, half of them MARN officials and the other half personnel who work outside the Ministry. Then, three-day training workshops were held on INF-RD Field Manual, with the participation of 97 technicians selected. Subsequently, the crews responsible for the field survey were designated and received rigorous training in the Field Manual and the Quality Control Manual.
- **ISNB**: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[7] to reduce non-sampling errors. The crew members for the fieldwork received training for implementing inventory methodology and QA/QC

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[2] Ministry of the Environment. 2015. Inventario nacional forestal de la República Dominicana: Measure and assess forests in order to understand their diversity, composition, volume and biomass. Field Manual. Forest Monitoring Unit. REDD7CCAD-GIZ. Regional Project 48 pages

[3] Ministry of the Environment. 2017. Assessment of the biomass and carbon content in non-forest systems in the Dominican Republic. Field Manual. Forestry Monitoring Unit REDD+ Preparation Project. 54 pages

[4]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

[5] MARN-GIZ. 2014. Manual de Campo del Inventario Nacional Forestal de la República Dominicana. Unidad de Monitoreo Forestal. Programa REDD CCAD GIZ. Santo Domingo, R.D. 61p. https://app.box.com/s/e0jf1lb49wpbd2981f9iwvvo2gvbf0av

[6] MARN-GIZ. 2018. Protocolo para el control de calidad del Inventario Nacional Forestal de Republica Dominicana 2018. Unidad de Monitoreo Forestal y Unidad de Gestión del Proyecto de Preparación REDD+ de la República Dominicana. 9p. https://app.box.com/s/b9uoly8bpn5n4b8xivhtv2ob3z2gslub

[7] MARN, 2017. Manual de Campo: Evaluación del contenido de biomasa y carbono en sistemas de No Bosque en la Republica Dominicana. Unidad de Monitoreo Forestal. Proyecto de Preparación de REDD+. 54p. https://app.box.com/s/056lacpm9rwyw2uh7a0aqz4a5yye9ol4

procedures. The inventory methodology was explained, and field practices were carried out, including measurements and sampling exercises. During this training, the crew leaders were confirmed according to their abilities and capacities.

- **Technical Correction Inventory:** The quality control procedures during the implementation of the survey of the 32 additional plots have been made following the NFI´s Field Manual and QA/QC procedures prepared by the Ministry of Environment and Natural Resources. The Forest Monitoring Unit of the Ministry has formed a quality control brigade that applied the QA/QC procedures in these additional plots; Likewise, the MARN QA/QC team and fieldwork crews were trained. Both teams worked together for two days, putting the inventory QA/QC protocol into practice.

Deforestation, Regeneration and Degradation activity data: The Dominican Republic MRV team prepared a Standard Operation Procedure (SOP) for the sample-based REDD+ activity data estimation[8]. This SOP includes a quality control and quality assurance (QA/QC) procedure and a visual interpretation decision tree for high-resolution and low-resolution imagery to ensure the analysts used the best imagery dataset during the photo-interpretation of the land-use class in the sampling point.

Soil Organic Carbon estimate: SOC Estimate for each forest type and non-forest class is based on the Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015 (**Technical Correction Inventory**). Description of QA/QC procedures are included in section 3.2 of the consultancy report of the Technical Correction Inventory [9].

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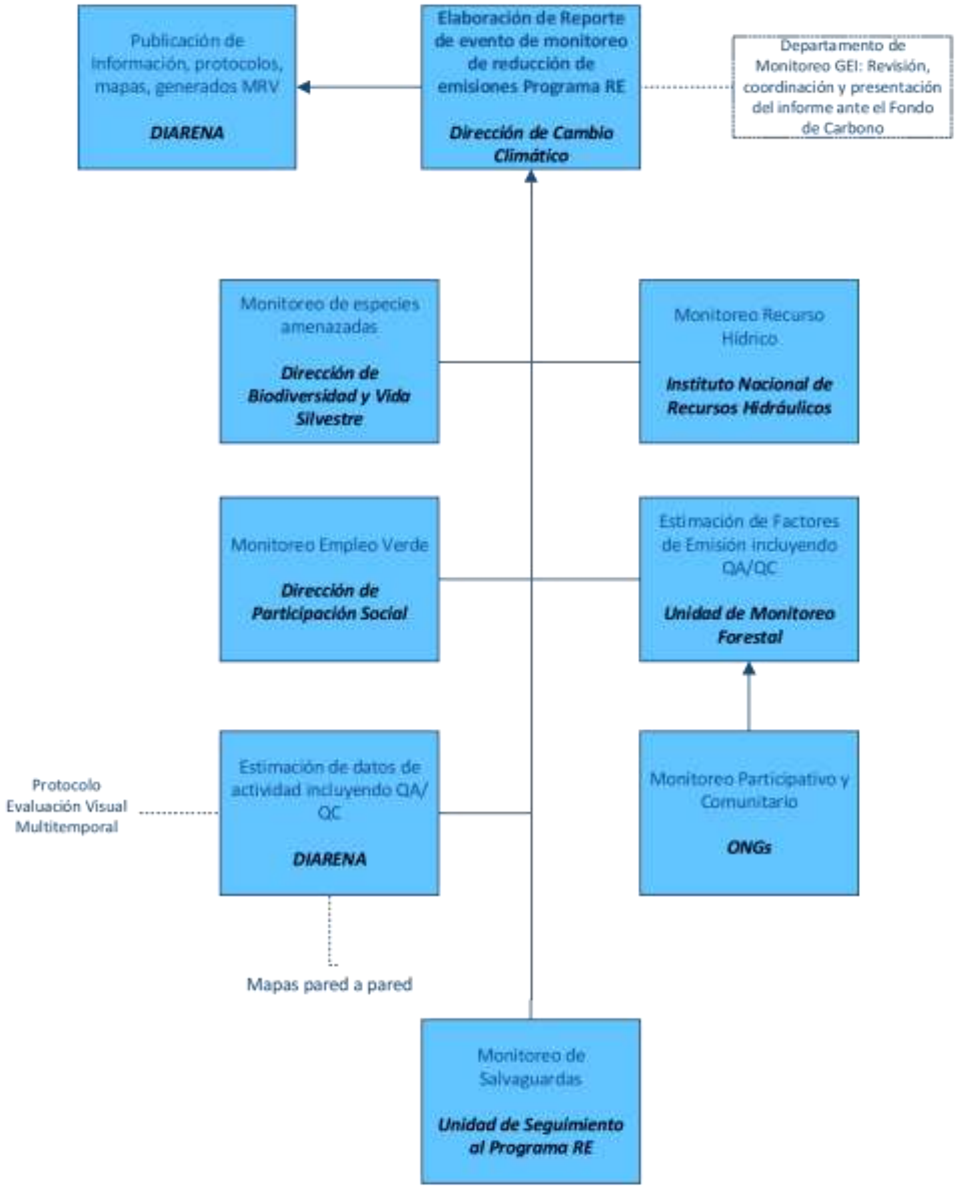
[8] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

[9]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6


Publicación de información, protocolos, mapas, generados MRV
DIARENA
Elaboración de Reporte de evento de monitoreo de reducción de emisiones Programa RE
Dirección de Cambio Climático
Departamento de Monitoreo GEI: Revisión, coordinación y presentación del informe ante el Fondo de Carbono
Monitoreo de especies amenazadas
Dirección de Biodiversidad y Vida Silvestre
Monitoreo Recurso Hídrico
Instituto Nacional de Recursos Hidráulicos
Monitoreo Empleo Verde
Dirección de Participación Social
Estimación de Factores de Emisión incluyendo QA/QC
Unidad de Monitoreo Forestal
Protocolo Evaluación Visual Multitemporal
Estimación de datos de actividad incluyendo QA/QC
DIARENA
Monitoreo Participativo y Comunitario
ONGs
Mapas pared a pared
Monitoreo de Salvaguardas
Unidad de Seguimiento al Programa RE

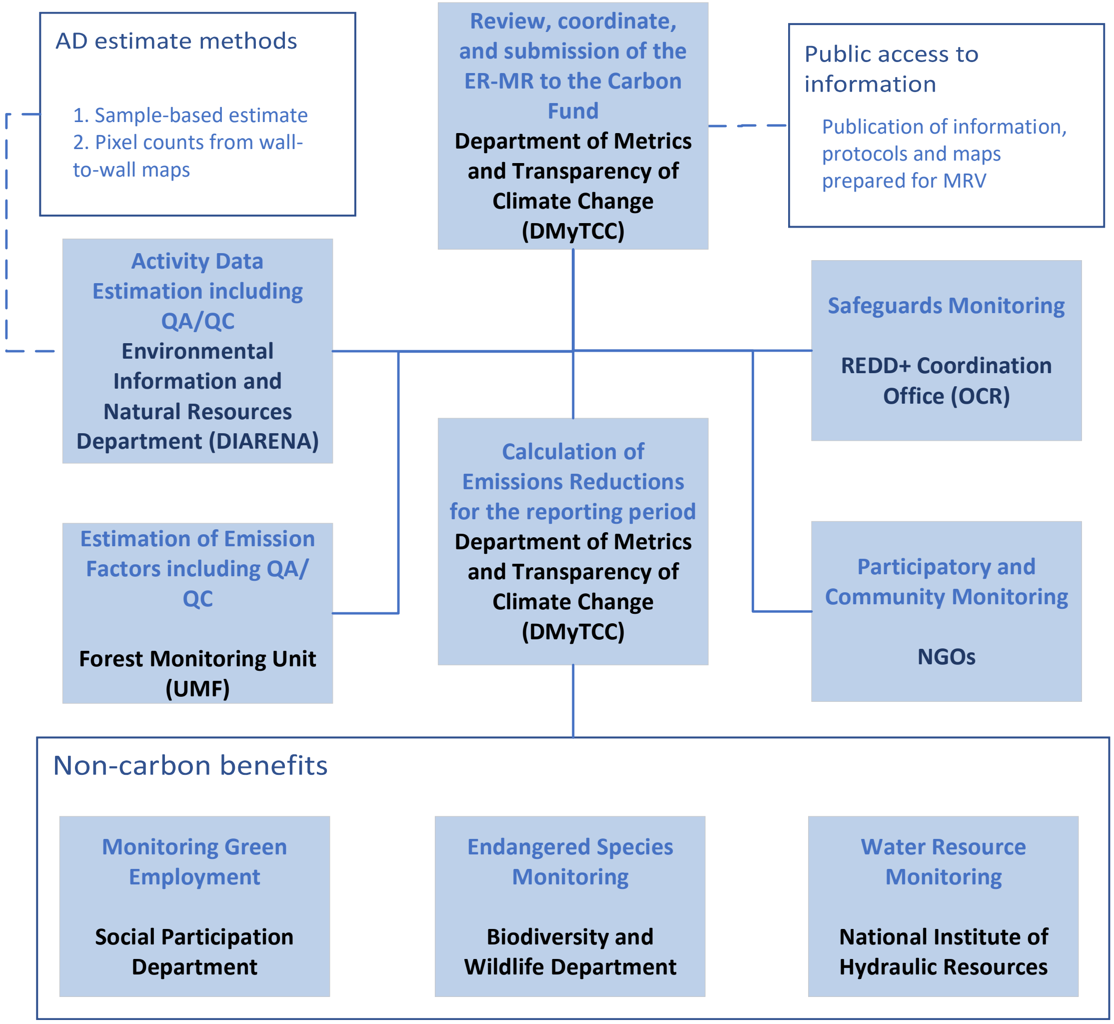


Figure 2-1: Organizational structure for ER-MR measurement, monitoring, and reporting in the Dominican Republic.

Table 2-1: Institutions in charge of the monitoring and reporting of the Emissions Reduction Program.

Monitoring function	Institution	Department	Technical team
Emissions reduction monitoring (Forest Monitoring system)			
Official reporting of emissions reduction to the Carbon Fund	The Ministry of Environment is the designated national authority and focal point for climate change	Coordinated by the Department of Climate Change of the Ministry of Environment	GHG Department (Revision, coordination and presentation of the ER Report to the Carbon Fund)
Publication of the information, protocols and maps generated in the monitoring system for the estimation of forest emissions reduction	Ministry of Environment	Environmental Information System, creation of REDD+ sub-portal operated by DIARENA (technical manager)	1 technical specialist
Estimation of emission and removal factors (including quality control and assurance and the management and estimation of uncertainty)	Ministry of Environment	Vice-Ministry of Forest Resources, Forest Monitoring Unit Estimation of rates of growth of secondary forest, forest fires, management plans	Forest Monitoring Unit 2 forest specialists, strengthening required (3 additional specialists). This team carries out the estimation of forest emissions for each monitoring event.
Estimation of activity data (including quality control and assurance and the management and estimation of uncertainty)	Ministry of Environment	DIARENA Generation of activity data and estimation of uncertainty, QA/QC	Technical team (3 remote sensing and GIS specialists). The technical team requires strengthening; a needs assessment is currently in progress.
Participatory and community monitoring	Non-Governmental Organizations Ministry of Environment	Forest Monitoring Unit (FMU)	NGO personnel Communities: monitoring of hot spots jointly with FMU 1 technician designated as Forest Monitoring liaison in 37 local offices, trained and equipped (instruments and equipment). (Office of the Minister of Environment)
Monitoring of multiple benefits			
Biodiversity (endangered species of flora)	Ministry of Environment	Department of Biodiversity and Wildlife	Ongoing monitoring programs
Water (INDRHI monitoring system)	INDRHI		63 telemetric water flow monitoring networks
Green Jobs	Ministry of Environment	Coordination by the Department of Social Participation	This requires institutional strengthening, and the Ministry of Labor must include this statistic
Monitoring of safeguards			
Natural habitats	Ministry of Environment	Monitoring Unit at the ERP.	Specialists from the Department of Social Participation 1 Social Specialist with responsibility for monitoring and following up on the MGAS and IRPF Support of the Technical Advisory Committee
Forest			
Involuntary resettlement			
Natural and cultural resources			
Local communities			

2.2 Measurement, monitoring, and reporting approach

Table 2.2 describes the set of tools developed by the Dominican Republic to estimate emissions and removal from deforestation, degradation, and forest regeneration. Also is provided a step-by-step description of the monitoring parameters used to establish the Reference Level and estimate Emissions and Emissions reductions during the Monitoring Period for the Carbon Pools and greenhouse gases selected in the ER-PD. The set of tools for emission and removal estimation can be accessed at the following link:

https://app.box.com/s/zqfnzgwtur4qtsde2in1ucrlwbg7krxn

Table 2-2: Step-by-step description of the monitoring parameter and data integration tools to establish the Reference Level and estimate Emissions and Emissions reductions during the Monitoring Period for the Carbon Pools and greenhouse gases selected in the ER-PD.

Monitoring parameters and Data Integration tools	Step	Description of the measurement and monitoring approach
Monitoring parameters	Step 0	The input dataset used to estimate net emissions for the reference and monitoring period include the following databases: • Forest and Non-Forest SOC sampling plots database[10] • Visual interpretation of hi-res imagery[11] • Forest biomass sampling plots database (National Forest Inventory (NFI)[12] and Additional sampling plots[13]) • Non-Forest biomass sampling plots database[14] • Forest cover maps time series 1984-2021[15]. The World Bank provided technical and financial support to develop the annual forest cover maps to prepare the FREL and the Emission Reduction estimated for the present monitoring report. This support includes preparing annual canopy cover maps required to assess forest degradation for the subsequent monitoring reports, following the same methods used to prepare the yearly maps for 1984-2021.
DatosDeActividad_PR.xlsx and DatosDeActividad_PM.xlsx	Step 1	The visual interpretation of hi-res imagery to determine land-use change used to estimate activity data for the Reference Period is included in the "***DatosReferencia***" sheet. This dataset is imported in CSV format from the database of interpreted points in Collect Earth Desktop.
	Step 2	Land-use change, degradation, deforestation, and regeneration analyses are included in the "***DatosReferencia***" sheet. These analyses are based on classification tables included in the "***TablasClasification***" sheet. Based on land-use change analyses, the calculation of deforestation, regeneration, and forest degradation is made in two activity data tools, one for Reference Period (PR) and another for the Monitoring Periods (PM). The activity data

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[10] The original database of soil organic carbon sampling plot data used to estimate the SOC linear decreasing rate estimate can be accessed at this link: https://app.box.com/s/tfu8h53kx7wtg7lyll5wff153h9q8itu

[11] The original database of visual interpretation of hi-res imagery to determine land-use change activity data during the reference and monitoring periods can be accessed at this link: https://app.box.com/s/tvfhjxaa5o9vdvkpak8cbivwjqcce5be

[12] The original NFI database used to estimate carbon densities can be accessed at this link: https://app.box.com/s/f6b71lxsdq7w2h1xwhh8ln3m0z6b95nl

[13] The original database of the 32 additional sampling plots used to estimate carbon densities can be accessed at this link: https://app.box.com/s/g6dq2i6yf5cdl2tqkye23m8srwkwn6su

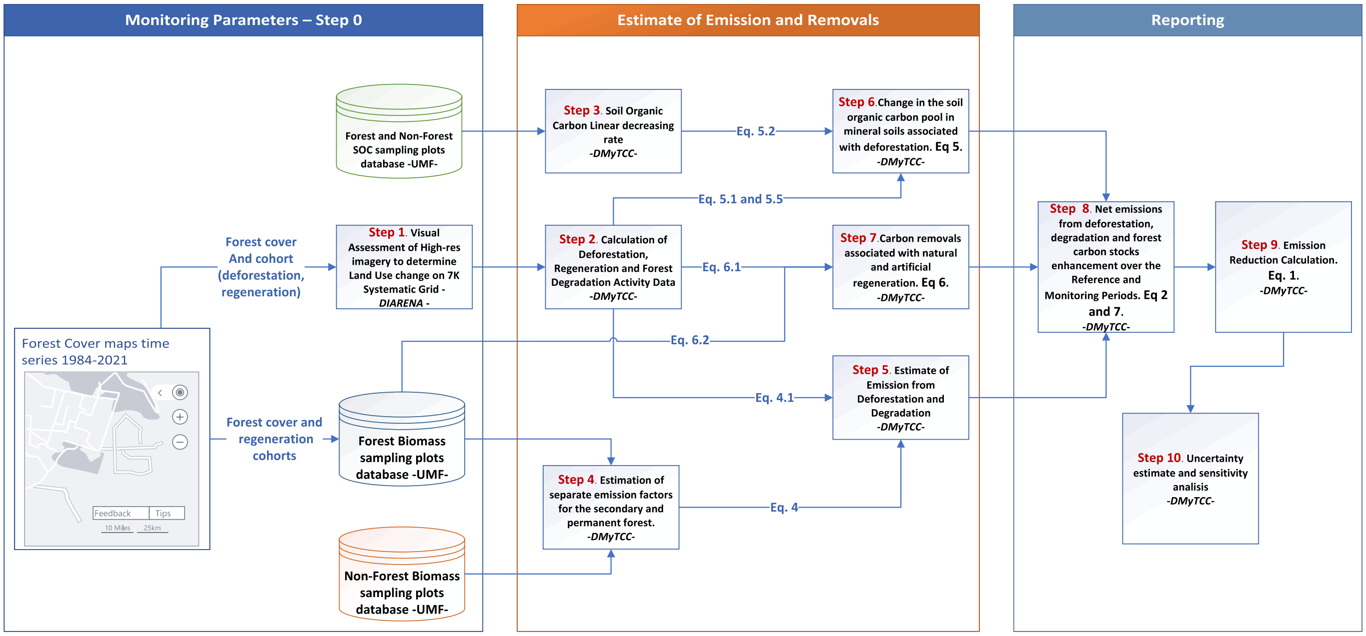
[14] The original Non-Forest Biomass Inventory database used to estimate carbon densities can be accessed at this link: https://app.box.com/s/g6dq2i6yf5cdl2tqkye23m8srwkwn6su

[15] The time series of forest cover maps used to stratify the forest biomass sampling plot according to forest age and category of canopy cover can be accessed at this link: https://app.box.com/s/bkfw90jc4y58s8htpkkxw8s287n04q5m

Monitoring parameters and Data Integration tools	Step	Description of the measurement and monitoring approach
		tool for PR includes the estimates for 1984-2000, 2001-2005, 2006-2015, and 2016-2018. PM tool includes 2016-2018, 2019-2021, 2022-2023, and 2024. Both tools are organized as follows: a. Deforestation: “***TF-OT***” sheet. b. Forest degradation: “***TF-TF***” sheet. c. Regeneration: “***OT-TF***” sheet. d. SOC change associated with deforestation: “***SOC TF-OT***” sheet.
COS_EF.xlsx	Step 3	Soil Organic Carbon linear decreasing rate estimate is in the “**SOCEF**” sheet of the SOC emission factor tool.
CarbonDensities_Tool.xlsx	Step 4	The estimate of different emission factors for the secondary and permanent forest is made in the “***CarbonDensities***” sheet. The calculation is based on the datasets included in the “***Non-Forest Biomass Plots Data***” and “***Forest Biomass Plots Data***” sheets.
“Deforestacion y Degradacion” Sheet in CalculoReduccionEmisionesRD.xlsx	Step 5	The estimate of emissions from deforestation and degradation is made in the “Deforestacion y Degradacion” sheet. The calculation is based on “***TF-OT***” and “***TF-TF***” sheet estimates made in the activity data tools (DatosDeActividad_PR.xlsx and DatosDeActividad_PM.xlsx) and “**CabonDensities**” sheet in CarbonDensities_Tools.xlsx.
EmisionesHeredadasSOC Sheet in CalculoReduccionEmisionesRD.xlsx	Step 6	Estimate of change in the soil organic carbon pool in mineral soils associated with deforestation is based on the “***SOC TF-OT***” sheet calculation made in the activity data tools (DatosDeActividad_PR.xlsx and DatosDeActividad_PM.xlsx) and Soil Organic Carbon linear decreasing rate estimate in the “***SOCEF***” sheet of the SOC emission factor tool (COS_EF.xlsx).
“RemocionesHeredadas” Sheet in CalculoReduccionEmisionesRD.xlsx	Step 7	The estimate of carbon removal associated with natural and artificial regeneration is made in the “***Remociones Heredadas***” sheet. The calculation is based on the “***OT-TF***” sheet calculation made in the activity data tool (DatosDeActividad.xlsx) and Removal Factors in the “***CarbonDensities***” sheet of the Emission factor tool (FREL-RD_FOREST-CarbonDensities_Tool.xlsx).
CalculoReduccionEmisionesRD.xlsx	Step 8	The estimate of net emissions from deforestation, degradation and forest carbon stocks enhancement over the Reference and Monitoring Periods is made in “***Calculo RE***¨ based on “**Deforestacion y Degradadacion**”, “***EmisionesHeredadas***” y “***RemocionesHeredadas***” sheets.
	Step 9	Emission reduction is also calculated in “***Calculo RE***” sheet. It is essential to clarify that a Pro-rata factor was applied to estimate the volume of ERs for the Reporting Period. The pro-rata factor corresponds to the fraction of the year 2021 between March 1st and December 31st .
EstimacionIncertidumbre.xlsx	Step 10	A results summary of the uncertainty estimates, and sensitivity analysis is in the ¨***Calculo RE***¨ sheet of EstimacionIncertidumbre.xlsx. This tool is based on the CalculoReduccionEmisiones.xlsx tool. This excel file was modified to calculate 10,000 iterations for the Emission Reduction estimate. The dataset with iterations for the different REDD+ activities considered in Emission calculation is included in the “***Iteraciones***” sheet. Emission Reduction Uncertainty consider the pro-rata factor application.

2.2.1 Line Diagram

Figure 2.2 shows a line diagram with relevant monitoring points, parameters, and data integration until reporting.



DIARENA: Environmental Information and Natural Resources Department
DMyTCC: Department of Metrics and Transparency of Climate Change
UMF: Forest Monitoring Unit

Figure 2-2: Line diagram with monitoring parameters, equations, and the integration of data until reporting.

2.2.2 Calculation

Equations and parameters used to calculate GHG emissions and removals are listed below. These equations show the steps from the measured input to the aggregation into final reported values. Changes to the original calculation described in the ER-PD have been highlighted. Description of the parameters may be found in Annex 4 – Section 8.3.

Emission reduction calculation ($\mathbf{ER_{ERP,t}}$)

$$\mathrm{ER_{ERP,t}} = (\mathrm{RL_t} - \mathrm{GHG_t}) \times \frac{44}{12} \qquad \textbf{Equation 1}$$

Where:

$\mathrm{ER_{ERP,t}}$ = Emission Reductions under the ER Program in year t; $tCO_2e*year^{-1}$.

$\mathrm{RL_t}$ = Net emissions of the RL from over the Reference Period; $tCO_2e*year^{-1}$. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.

$\mathrm{GHG_t}$ = Monitored net emissions at year t; $tCO_2e*year^{-1}$;

$\frac{44}{12}$ = Conversion of C to CO2

Reference Level ($\mathbf{RL_t}$)

The RL estimation may be found in Annex 4, yet a description of the equations is provided below.

E ($\mathrm{RL_t}$) are estimated as the net change in total biomass carbon stocks and organic carbon pool in mineral soils during the reference period.

$$\mathrm{RL}_t = \frac{\Delta C_{B_{RP}} + \Delta \mathrm{C}_{\mathrm{DegB}_{RP}} + \sum_{\mathrm{t}}^{\mathrm{RP}} \Delta \mathrm{C}_{\mathrm{RB_t}} + \sum_{\mathrm{t}}^{\mathrm{RP}} \Delta \mathrm{C}_{Mineral_{\mathrm{t}}}}{RP} \qquad \textbf{Equation 2}$$

Where:

$\Delta \mathrm{C_{B_{RP}}}$ = Change in total biomass carbon stocks in forest lands converted to other land-use category during the Reference period, in tC;

$\Delta \mathrm{C}_{\mathrm{DegB}_{RP}}$ = Change in total biomass carbon stocks in forest lands that remains as forest during the reference period, in tC;

$\Delta \mathrm{C_{Mineral_t}}$ = Annual change in the soil organic carbon pool in mineral soils associated with deforestation; $tC*year^{-1}$;

$\Delta \mathrm{C_{RB_t}}$ = Annual change in total biomass carbon stocks in non-forest lands converted to forest lands categories at year t; $tC*year^{-1}$;

RP = Reference period; years.

Change in total biomass carbon stocks in forest lands converted to other land-use (Deforestation):

Following the 2006 IPCC Guidelines, the change in total biomass carbon stocks forest (land converted to other land-use,) category ($\Delta \mathrm{C_{B_t}}$) would be estimated through the following equation:

$$\Delta \mathrm{C_{B_t}} = \Delta \mathrm{C_G} + \Delta \mathrm{C_{CONVERSION}} - \Delta \mathrm{C_L} \qquad \textbf{Equation 3}$$

Where:

ΔC_{B_t} Annual change of total biomass carbon stocks during the period, in tC*year^{-1};

ΔC_G Increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tC per hectare per year;

$\Delta C_{CONVERSION}$ Initial change in carbon stocks in biomass on land converted to another land-use category, in tC per hectare; and

ΔC_L Decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tC per hectare per year.

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document for applying IPCC Guidelines and guidance in the context of REDD+[16], the above equation will be simplified, and it will be assumed that the change in total biomass carbon stocks (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$). Considering equation 2.16 of the 2006 IPCC GL for estimating ($\Delta C_{CONVERSION}$) the change of biomass carbon stocks during the Reference Period was calculated with the following equation:

$$\Delta C_{B_{RP}} = \sum_{\mathbf{j,i}} \left(B_{\mathrm{Before,j}} - B_{\mathrm{After,i}}\right) \times A(\mathrm{j,i})_{\mathrm{RP}}$$ **Equation 4**

Where:

$\Delta C_{B_{RP}}$ Change of biomass carbon stocks during the Reference Period, in tC.

$A(\mathrm{j,i})_{\mathrm{RP}}$ Area converted from forest type j to non-forest type i during the Reference Period, in hectares per year.

$$A(\mathrm{j,i})_{\mathrm{RP}} = \frac{P(\mathrm{j,i})_{\mathrm{RP}}}{N} \times AA$$ **Equation 4.1**

$P(\mathrm{j,i})_{\mathrm{RP}}$: Number of points converted from forest type j to non-forest type I during the Reference Period, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program accounting area (in hectares)

In this case, ninety-six forest land conversions are possible resulted from the combinations of the following forest and non-forest types:

Forest type	Non-forest types
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest. Three canopy cover categories: • Intact forest (>85%). • Degraded forest (60-85%), and • Very degraded forest (30-60%) Two cohorts of secondary forest • Cohort 4-21 years, and • Cohort 22-44 years.	Five types of non-forest land are considered: • Cropland. • Grassland. • Settlement; and • Woody vegetation.

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[16] https://www.reddcompass.org/documents/184/0/MGD2.0_English/c2061b53-79c0-4606-859f-ccf6c8cc6a83

Technical corrections applied this parameter: The deforestation activity data was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions.

$B_{Before,j}$ Total biomass of forest type j before conversion/transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47).

Technical corrections applied to this parameter: The original calculation of change in biomass carbon stock only considered biomass density of the forest type, ignoring the forest's degradation condition. Also, this calculus did not consider the stand age. Carbon density in secondary forests varies with age, and primary forests usually present carbon densities higher than secondary. Ignoring forest degradation and forest age in the measure of change in biomass carbon stock overestimates the emission from deforestation. Therefore, total biomass was recalculated for each canopy cover category (>85%, 60-85%, and 30-60%) into each permanent forest type. Also, total biomass was calculated for each forest cohort.

$B_{After,i}$ Total biomass of non-forest type i after conversion, in tons C per ha. This is equal to the sum of aboveground biomass (AGB_{after}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{after}), litter (L_{after}) and death wood (DW_{after}) and it is defined for each of the five non-forest IPCC Land Use categories. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47).

Technical corrections applied to this parameter: Total biomass of non-forest land uses did not consider the same carbon pools included in the $B_{before,j}$. Carbon densities for non-forest IPCC Land Use Categories were recalculated to ensure carbon pools consistency between $B_{after,i}$ and $B_{before,j}$.

Change in the soil organic carbon pool in mineral soils associated with deforestation:

The total carbon stock change estimated in the ERPD was incorrect. It was assumed an EF of only 1/20 of SOC stock for the Reference Period (RP). The Dominican Republic ERPD did not include emissions from SOC of deforested areas before the reference period. A 20-year default legacy period was not used to estimate emissions from SOC of each deforested area during the Reference Period either.

The annual change in the SOC pool was technically corrected. The updated estimate of SOC pool change was made according to the following:

- SOC change was calculated based on Equation 2.25 from the 2006 IPCC Guidelines, Volume 4, Chapter 2.
- SOC emissions associated with deforestation now include the land-use changes occurring in the Reference Period and the emissions resulting from land-use changes that occurred in previous years ("legacy emissions"). Full implementation of this approach was possible since it was available a long time series of deforestation activity data that let going back at least 20 years before the start of the Reference Period to correctly estimate legacy emissions.
- It was assumed that the Soil organic C stock change during the transition to a new equilibrium SOC occurs in a linearly over a period of 20 years.
- The Land Units represent yearly classes from the land use change analysis used in setting the reference level.
- Land Units maintain the same forest types as the ones used in the land use change analysis provided in the ER-PD.

In accordance with the approach provided in the 2006 IPCC Guidelines, the following matrices and Equation 5 were used for determining the annual change in the soil organic pool associated with deforestation:

Land use change matrix

Land Unit	Year 1	⋯	Year n	⋯	Year 20	⋯	Year 20+n
$\boldsymbol{LU_1}$	$\mathrm{A(j,i)}_{1,1}$	⋯	$\mathrm{A(j,i)}_{1,n}$	⋯	$\mathrm{A(j,i)}_{1,20}$		
⋮			⋮	⋮	⋮	⋮	
$\boldsymbol{LU_n}$			$\mathrm{A(j,i)}_{n,n}$	⋯	$\mathrm{A(j,i)}_{n,20-n}$	⋯	$\mathrm{A(j,i)}_{n,20+n}$
Stable Forest	SF_J		$SF(j)_{n-1} - \sum_{LU=1}^{n} A(j,i)_n$	⋯	$SF(j)_{19} - \sum_{LU=1}^{n} A(j,i)_{20}$	⋯	$SF(j)_{19+k} - \sum_{LU=1}^{n} A(j,i)_{20+n}$

×

SOC Value for each LU in a particular year

Land Unit	Year 1	⋯	Year n	⋯	Year 20	⋯	Year 20+n
$\boldsymbol{LU_1}$	$SOC_j - S(j,i)$	⋯	$SOC_{J_{1,n-1}} - S(j,i)$	⋯	$SOC_{J_{1,19}} - S(j,i)$		
⋮		⋮	⋮	⋮	⋮	⋮	
$\boldsymbol{LU_n}$			$SOC_j - S(j,i)$	⋯	$SOC_{J_{n,19-n}} - S(j,i)$	⋯	$SOC_{J_{n,19+n}} - S(j,i)$
Stable Forest	SOC_J	⋯	SOC_J	⋯	SOC_J	⋯	SOC_J

=

Multiplying the two tables leads to the following results for the application in Equation 2.25 to the Reference Level

Land Unit	Year 1	⋯	Year n	⋯	Year 20	⋯	Year 20+n
$\boldsymbol{LU_1}$	$\mathrm{TS(j,i)}_{1,1}$	⋯	$\mathrm{TS(j,i)}_{1,n}$	⋯	$\mathrm{TS(j,i)}_{1,20}$	⋯	
⋮			⋮	⋮	⋮	⋮	
$\boldsymbol{LU_n}$			$\mathrm{TS(j,i)}_{n,n}$	⋯	$\mathrm{TS(j,i)}_{n,20-n}$	⋯	$\mathrm{TS(j,i)}_{n,20+n}$
Stable Forest	$\mathrm{TS(j)}_1 + \sum_{LU=1}^{n} TS(j,i)_1$	⋯	$\mathrm{TS(j)}_n + \sum_{LU=1}^{n} TS(j,i)_n$	⋯	$\mathrm{TS(j)}_{20} + \sum_{LU=1}^{n} TS(j,i)_{20}$	⋯	$\mathrm{TS(j)}_{20+n} + \sum_{LU=1}^{n} TS(j,i)_{20+n}$

Applying the IPCC approach, annual changes in the Soil Organic Carbon pool are calculated as total SOC for year 0 – total SOC for the previous year (0-1), using the Equation 5.

$$AC_{Mineral_t} = \left[\mathrm{TS(j)}_{n-1} + \sum_{LU=1}^{n} TS(j,i)_{n-1}\right] - \left[\mathrm{TS(j)}_{n} + \sum_{LU=1}^{n} TS(j,i)_{n}\right] \qquad \textbf{Equation 5}$$

Where:

$\mathrm{A(j,i)_{LU}}$ Area converted/transited from forest type j to non-forest type i of the Land Unit LU, in hectares per year.

$$\mathrm{A(j,i)_{LU}} = \frac{\mathrm{P(j,i)_{LU}}}{\mathrm{N}} \times \mathrm{AA} \qquad \textbf{Equation 5.1}$$

$\mathrm{P(j,i)_{LU}}$: Number of points converted from forest type j to non-forest type i in the Land Unit LU, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program Accounting Area (in hectares)

In this case, four forest land conversions are possible resulted from the combinations of the following forest and non-forest types:

Forest type	Non-forest types
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest.	One type of non-forest land is considered: • Non-forest land use

<u>Technical corrections applied to this parameter</u>: The deforestation activity data was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions.

$S(j,i)$ Soil Organic Carbon Linear decreasing rate for transition j to i, in tons of C per ha per year.

$$S(j,i) = \frac{SOC_j - SOC_i}{D} \qquad \textbf{Equation 5.2}$$

$\mathrm{SOC_j}$ Soil Organic Carbon of forest type j before conversion/transition, in tons of C per ha.

$\mathrm{SOC_i}$ Soil Organic Carbon of non-forest type i after conversion, in tons of C per ha.

<u>Technical corrections applied to these parameters</u>: The SOC values (before and after forest transition) were technically corrected to replace the original estimates sourced from National Forest Inventory. The soil organic carbon pool estimates in the NFI of the Dominican Republic presented errors and methodological limitations.

NFI soil samples were collected from the upper 15 cm of soil. However, the soil organic carbon stock was calculated from the upper 30 cm. Generally, the SOC decreases with sampling depth. Also, the gravel content was ignored during the SOC pool calculation. Rock fragments do not have organic carbon, and the coarse stone percentage is sometimes very high. Calculate SOC at 30 cm using soil values taken at 15cm, and without considering the coarse volumetric ratio, overestimate the pool of SOC and, consequently, the deforestation emission factor.

To avoid the overestimation of SOC, two hundred sixty paired plots were established (130 in forest lands and 130 in non-forest use) to measure Soil Organic Carbon before and after deforestation, comparing the SOC between pairs by type of vegetation.

D Time in years where SOC_j decrease linearly to a new equilibrium SOC_i. A period of twenty years is assumed for all types of forest to non-forest conversions.

$TS(j,i)$ Soil organic carbon remaining in the Land Unit in the transition j to I, in tons of C.

$$TS(j,i)_{n,n} = \mathrm{A(j,i)_{n,n}} \times \left(SOC_j - S(j,i)\right)$$ **Equation 5.3**

$TS(j)$ Soil organic carbon remaining in the Stable Forest type j, in tons of C.

$$TS(j)_{n,n} = \mathrm{A(j)_{n,n}} \times SOC_j$$ **Equation 5.4**

$\mathrm{A(j)}$ Area of Stable Forest type j, in hectares.

$$\mathrm{A(j)} = \frac{\mathrm{P(j)}}{\mathrm{N}} \times \mathrm{AA}$$ **Equation 5.5**

$\mathrm{P(j)}$: Number of points from forest type j, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Accounting Area (in hectares)

Technical corrections applied to this parameter: The Stable Forest area estimate was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions.

Carbon removals associated with natural and artificial regeneration, including plantations (Enhancement of forest carbon stocks):

Equation 6 is used to calculate annual carbon removals associated with regeneration. The net annual carbon removals are computed using equations 2.15 and 2.16 from the 2006 IPCC Guidelines, Volume 4, Chapter 2 (Equations 3 and 4). These equations are simplified by assuming that the conversion from non-forest to forest occurs during a period from average carbon stocks in non-forest to average carbon stocks in secondary forests and is equal to the net annual increase in total biomass (ΔC_G-ΔC_L). The removal estimate considers changes in carbon stocks in above- and below-ground biomass, dead organic matter, and litter. SOC in mineral soils is omitted.

The dataset used to estimate the annual change in carbon stocks in biomass on land converted to forest includes carbon densities of secondary forests. Secondary forest's age ranges from 4 to 42 years. Stands' age was determined with change detection maps based on a 37-year time series of 30-m, annual-resolution estimates of forest probability in each pixel. Forest losses and gains were detected by applying a two-sample z-test in a moving kernel over time, registering the year of change detection (see the map in figure 2-3). Considering the range of age of the secondary forest sampling plots, for all forest types, a period of 44 years is assumed for the stand to grow from the carbon stock levels of non-forest to the average biomass and litter pools of the secondary forest.

Land units have been created to track the area converted to forest land in a specific year and remains as forest during the reference and crediting period, considering deforestation in the secondary forest cohort. The Removals are calculated by multiplying the area of land planted with the tons of C per hectare.

Land Unit	Year 1	⋯	Year n	⋯	Year 44	⋯	Year 44+n
$\boldsymbol{LU_1}$	$R(\mathrm{j,i})_{1,1} \times \Delta C_{RB_i}$	⋯	$\mathrm{R(j,i)_{1,n}} \times \Delta C_{RB_i}$	⋯	$\mathrm{R(j,i)_{1,44}} \times \Delta C_{RB_i}$		
⋮			⋮	⋮	⋮	⋮	

$$\left|\begin{array}{lccccccc} \boldsymbol{LU_n} & & & \mathrm{A(j,i)_{n,n}} \times \Delta C_{RB_i} & \cdots & \mathrm{A(j,i)_{n,44-n}} \times \Delta C_{RB_i} & \cdots & \mathrm{A(j,i)_{n,44+n}} \times \Delta C_{RB_i} \\ \text{Stable Forest} & \sum_{LU=1}^{n} R(j,i)_n \times \Delta C_{RB_i} & \cdots & \sum_{LU=1}^{n} R(j,i)_n \times \Delta C_{RB_i} & \cdots & \sum_{LU=1}^{n} R(j,i)_{44} \times \Delta C_{RB_i} & \cdots & \sum_{LU=1}^{n} R(j,i)_{20+n} \times \Delta C_{RB_i} \end{array}\right|$$

$$\Delta C_{RB_t} = \sum_{LU=1}^{n} R(j,i)_n \times \Delta C_{RB_i} \qquad \textbf{Equation 6}$$

Where:

$R(\mathrm{j,i})_{\mathrm{LU}}$ Area converted from non-forest type *j* to forest type *i* of the Land Unit LU, in hectares per year.

$$\mathrm{R(j,i)_{LU}} = \frac{\mathrm{P(j,i)_{LU}}}{\mathrm{N}} \times \mathrm{AA} \qquad \textbf{Equation 6.1}$$

$\mathrm{P(j,i)_{LU}}$: Number of points converted from non-forest type *j* to forest type *i* in the Land Unit LU, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program Accounting Area (in hectares)

In this case, four forest land conversions are possible resulted from the combinations of the following forest and non-forest types:

Non-forest types *j*	Forest type *i*
One type of non-forest land is considered: • Grasslands	Four forest types: • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest.

Technical corrections applied to this parameter: The area estimate of other land converted to the forest was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions.

$$\Delta C_{RB_i} = \frac{B_{non-forest} - B_{forest_i}}{m} \qquad \textbf{Equation 6.2}$$

ΔC_{RB_i}	Annual change in carbon stocks in biomass on land converted to forest *i*, in tC per ha per year;
$B_{non-forest}$	Total biomass of non-forest type before conversion/transition, in tons of C per ha. This is equal to the sum of aboveground biomass of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass, litter and death wood. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47);
B_{forest_i}	Total biomass of forest type *i* after conversion, in tons of C per ha. This is equal to the sum of aboveground biomass of trees with a diameter at breast high (dbh)

higher than 2 cm, belowground biomass, litter and death wood. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47);

m Time elapsed to reach B_{forest_i}, in years.

Technical corrections applied to these parameters: The ΔC_{RB_i}values were technically corrected to replace the original estimates sourced scientific literature. Now the net annual carbon removals are computed using equations 2.15 and 2.16 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. These equations are simplified by assuming that the conversion from non-forest to forest occurs during a period from average carbon stocks in non-forest to average carbon stocks in secondary forests and is equal to the net annual increase in total biomass (ΔC_G-ΔC_L).

Based on FC maps, a forest cover change analysis was prepared, and secondary forest cohorts were mapped into two categories: i. Secondary Forest cohort 4-22 years, and ii. Secondary Forest cohort 22-44 years. All forest inventory plots in forest and tree-shaded crops were classified into these two categories. By forest type, carbon content was directly derived from the biomass sampling plots database (average and 90%CI). In secondary forest types with less than ten sampling plots, additional forest plots were inventoried. A series of 32 secondary sampling units were inventoried in 2021, and age was determined from different sources: interviews and satellite information and secondary data.

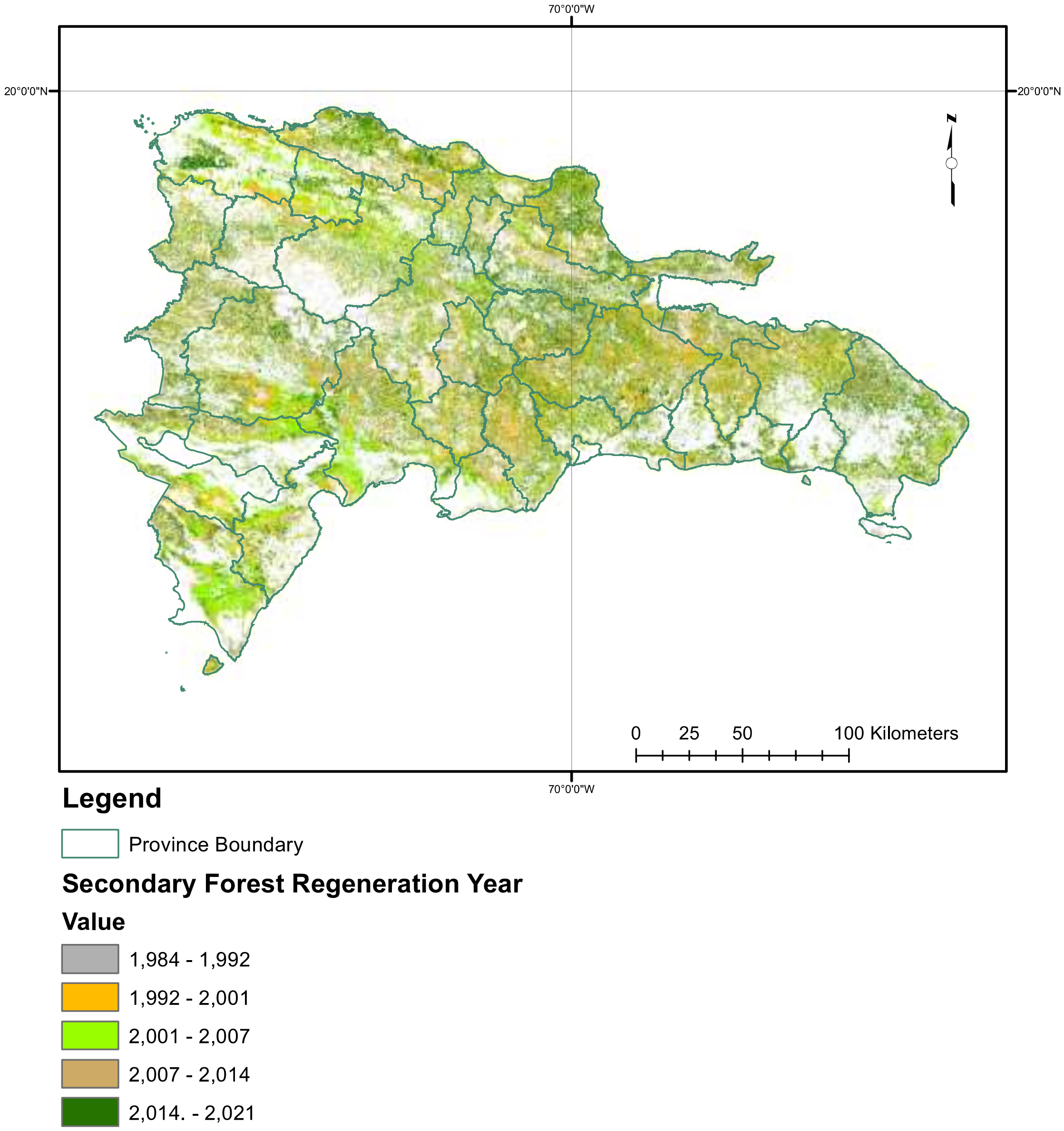

Figure 2-3: Regeneration year of native forest in the Dominican Republic during 1984-2021. Forest cover gain map developed by terraPulse (www.terrapulse.com) based on the analysis of annual stacks of Landsat imagery. Stands' age was determined with change detection maps based on a 37-year time series of 30-m, annual-resolution estimates of forest probability in each pixel. Forest losses and gains were detected by applying a two-sample z-test in a moving kernel over time, registering the year of change detection

Change in total biomass carbon stocks in forest lands that remains as forest (Forest Degradation):

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document, for applying IPCC Guidelines and guidance in the context of REDD+, the equation 2.16 of the 2006 IPCC GL can be simplified by assuming that the change in total biomass carbon stocks (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$). Thus, the change of biomass carbon stocks in forest lands that remains as forest during the Reference Period was calculated with the **Equation 4**:

$$\Delta C_{DegB_{RP}} = \sum_{\mathbf{j,i}} \left(B_{Before,j} - B_{After,i}\right) \times Deg(j,i)_{RP}$$ **Equation 7.2**

Where:

$\Delta C_{DegB_{RP}}$ Change in total biomass carbon stocks in forest lands that remains as forest during the reference period, in tC.

$Deg(j,i)_{RP}$ Area converted from forest with canopy cover j to forest with canopy cover i during the Reference Period, in hectares.

$$Deg(j,i)_{RP} = \frac{P(j,i)_{RP}}{N} \times AA$$ **Equation 4.3**

$P(j,i)_{RP}$: Number of points converted from forest with canopy cover *j* to forest with canopy cover *i* during the Reference Period, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program accounting area (in hectares)

Activity data for degradation and carbon enhancement in the permanent forest were derived with a systematic sampling procedure (7,697 Permanent Sampling Units) and Forest Cover (FC) annual maps. Twenty-eight canopy cover transitions were identified resulting from the combinations of the following forest types and canopy cover categories:

Forest type	Canopy cover category
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest. • Agricultural tree-shaded crops	Three canopy cover categories: • Intact forest (>85%). • Degraded forest (60-85%), and • Very degraded forest (30-60%) • Agricultural tree-shaded crops

<u>Technical corrections applied this parameter</u>: FC maps were used to determine the canopy cover class or secondary forest's age of all biomass inventory plots used to estimate carbon content by forest type and degradation class. With FC maps information was possible to assign each Biomass plot the canopy cover class 30-60%, 60-85%, and >85%. Canopy cover activity data (degradation/enhancement) was also estimated from canopy cover maps to ensure coherence between activity data and carbon density estimates. Sample-based area estimation method was used to calculate activity data. Forest cover and its probability were extracted from FC maps for each sampling point in a systematic grid. A denser sampling grid was used, 2.5 x 2.5 km, instead of the original 5 x 5 km grid. This 2.5 x 2.5 km sampling grid is also used to visually assess land-use change over high-res imagery.

$B_{Before,j}$ Total biomass of forest type *j* before transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type.

$B_{After,i}$ Total biomass of forest type *i* after transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{after}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{after}), litter (L_{after}) and death wood (DW_{after}) and it is defined for each forest type.

Technical corrections applied to this parameter: The original calculation of emissions and removals resulting from canopy cover loss and gain was based on AGB-canopy cover linear regression models for broadleaf, dry, and pine forests. These models were applied to estimate the loss and gain of biomass during the reference period. Total biomass was recalculated for each canopy cover category (>85%, 60-85%, and 30-60%) for each forest type (omitting secondary forests). All forest inventory plots in forest lands were classified into four categories based on terraPulse data. By forest type and degradation class, carbon content was directly derived from the biomass sampling plots database (average and 90%CI).

Monitored emissions ($\mathrm{GHG_t}$)

Annual gross GHG emissions over the monitoring period in the Accounting Area ($\mathrm{GHG_t}$) are estimated as the in total biomass carbon stocks and organic carbon pool in mineral soils during the monitoring period.

$$GHG_t = \frac{\Delta C_{B_{MP}} + \Delta \mathrm{C}_{\mathrm{DegB}_{MP}} + \sum_{\mathrm{t}}^{\mathrm{MP}} \Delta \mathrm{C}_{\mathrm{RB_t}} + \sum_{\mathrm{t}}^{\mathrm{MP}} \Delta \mathrm{C}_{Mineral_{\mathrm{t}}}}{T}$$ **Equation 8**

Where:

$\Delta \mathrm{C}_{\mathrm{B_{MP}}}$ = Change in total biomass carbon stocks in forest lands converted to other land-use category during the monitoring period, in tC;

$\Delta \mathrm{C}_{\mathrm{DegB}_{RP}}$ = Change in total biomass carbon stocks in forest lands that remains as forest during the monitoring period, in tC;

$\Delta \mathrm{C}_{\mathrm{Mineral_t}}$ = Annual change in the soil organic carbon pool in mineral soils associated with deforestation; tC*year^{-1};

$\Delta \mathrm{C}_{\mathrm{RB_t}}$ = Annual change in total biomass carbon stocks in non-forest lands converted to forest lands categories at year t; tC*year^{-1};

T = Number of years during the monitoring period; dimensionless.

Change in total biomass carbon stocks in forest lands converted to other land-use (Deforestation):

Following the 2006 IPCC Guidelines, the annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta \mathrm{C_B}$) is estimated through **Equation 3 4** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta \mathrm{C}_{\mathrm{B}_{MP}} = \sum_{\mathbf{j,i}} \left(\mathrm{B_{Before,j}} - \mathrm{B_{After,i}}\right) \times \mathrm{A(j,i)_{MP}}$$ **Equation 9**

Where:

$\mathrm{A(j,i)_{MP}}$ Area converted from forest type j to non-forest type i during the Monitoring Period, in hectares per year.

$$\mathrm{A(j,i)_{MP}} = \frac{\mathrm{P(j,i)_{MP}}}{\mathrm{N}} \times \mathrm{AA}$$ **Equation 9.1**

$\mathrm{P(j,i)_{MP}}$: Number of points converted from forest type j to non-forest type I during the Monitoring Period, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program accounting area (in hectares)

In this case, ninety-six forest land conversions are possible resulted from the combinations of the following forest and non-forest types:

Forest type	Non-forest types
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and	Five types of non-forest land are considered: • Cropland. • Grassland. • Settlement; and

- Mangrove forest. Three canopy cover categories: - Intact forest (>85%). - Degraded forest (60-85%), and - Very degraded forest (30-60%) Two cohorts of secondary forest - Cohort 4-21 years, and - Cohort 22-44 years.	- Woody vegetation.

$B_{Before,j}$	Total biomass of forest type j before conversion/transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47);
$B_{After,i}$	Total biomass of non-forest type i after conversion, in tons C per ha. This is equal to the sum of aboveground biomass (AGB_{after}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{after}), litter (L_{after}) and death wood (DW_{after}) and it is defined for each of the five non-forest IPCC Land Use categories. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47).

Change in the soil organic carbon pool in mineral soils associated with deforestation:

The matrices and **Equations 5, 5.1, 5.2, 5.3, 5.4,** and **5.5** used for determining the annual change in the soil organic pool associated with deforestation in the reference period were also used for the monitoring period.

Carbon removals associated with natural and artificial regeneration, including plantations (Enhancement of forest carbon stocks):

The matrices **and Equations 6, 6.1, and 6.2** used to calculate annual carbon removals associated with regeneration in the reference period were also used for the monitoring period.

Change in total biomass carbon stocks in forest lands that remains as forest (Forest Degradation):

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document, for applying IPCC Guidelines and guidance in the context of REDD+, the equation 2.16 of the 2006 IPCC GL can be simplified by assuming that the change in total biomass carbon stocks (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$). Thus, the change of biomass carbon stocks in forest lands that remains as forest during the Monitoring Period was also calculated with the **Equation 4**:

$$\Delta C_{DegB_{RP}} = \sum_{j,i} \left(B_{Before,j} - B_{After,i} \right) \times Deg(j,i)_{MP}$$ **Equation 9.2**

Where:

$\Delta C_{DegB_{MP}}$	Change in total biomass carbon stocks in forest lands that remains as forest during the Monitoring period, in tC.
$Deg(j,i)_{MP}$	Area converted from forest with canopy cover j to forest with canopy cover i during the Monitoring Period, in hectares per year.

$$Deg(j,i)_{MP} = \frac{P(j,i)_{MP}}{N} \times AA$$ **Equation 9.3**

$\mathrm{P(j,i)_{RP}}$: Number of points converted from forest with canopy cover *j* to forest with canopy cover *i* during the Monitoring Period, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program accounting area (in hectares)

In this case, twenty-eight canopy cover transitions forest are possible resulted from the combinations of the following forest and canopy cover categories:

Forest type	Canopy cover category
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest. • Agricultural tree-shaded crops	Three canopy cover categories: • Intact forest (>85%). • Degraded forest (60-85%), and • Very degraded forest (30-60%) • Agricultural tree-shaded crops

$\mathrm{B_{Before,j}}$ Total biomass of forest type *j* before transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47);

$\mathrm{B_{After,i}}$ Total biomass of forest type *i* after transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{after}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{after}), litter (L_{after}) and death wood (DW_{after}) and it is defined for each forest type. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47).

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3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

Carbon densities of forest and non-forest types, and annual change in carbon stocks are calculated from the same sources and were measured at the time of the ERPD and will remain fixed during the Crediting period.

Parameters:	$B_{Before,j}$; $B_{After,i}$; ΔC_{RB_i}
Description:	$B_{Before,j}$: Total biomass of forest type j before conversion, **Equation 4.** $B_{After,i}$: Total biomass of non-forest type i after conversion, **Equation 4.** ΔC_{RB_i}: Annual change in carbon stocks in biomass on land converted to forest *i*, **Equation 6.2.**
Data units:	$B_{Before,j}$; $B_{After,i}$ tons of C per ha ΔC_{RB_i} tons of C per ha per year
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Spatial level of data**: National **Sources of data**: Three sources of data were used to estimate total biomass in each of the land uses and the emission factors in the land-use change categories: a. The National Forest Inventory (**NFI**)[17], b Assessment of Biomass and Carbon Content in Non-Forest Cover in the Dominican Republic" (**ISNB**)[18], and c. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015 (**Technical Correction Inventory**) [19]. **Methods**: The inventories were compiled using the same methodology, sampling unit, and nested plots in order to determine carbon density for each component recognized as a sink. Each carbon pool is estimated using the database at the tree level, taking the area of the sampling units into account. Allometric models used to estimate the above-ground biomass of the components recorded in these three inventories are listed above. Due to there being no specific allometric equations for broadleaf forests in the Dominican Republic, above-ground biomass (AGB) calculations are carried out using the allometric equations of Chave et al. (2014)[20] in the three inventories. For pine trees, a local allometric equation is used. Allometric equations developed in Nicaragua and Costa Rica are used for coffee, cocoa, coconut, mango, avocado, and guava. The Cairns et al. (1997) [21] equation is used to quantify below-ground biomass roots.. With these three surveys a total of 573 plots[22] were collected, with estimations of the above-ground biomass (AGB), dead material (DM) and litter (L). Total biomass of forest types and non-forest types is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type.

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[17] Ministry of the Environment. 2015. Inventario nacional forestal de la República Dominicana: Measure and assess forests in order to understand their diversity, composition, volume and biomass. Field Manual. Forest Monitoring Unit. REDD7CCAD-GIZ. Regional Project 48 pages

[18] Ministry of the Environment. 2017. Assessment of the biomass and carbon content in non-forest systems in the Dominican Republic. Field Manual. Forestry Monitoring Unit REDD+ Preparation Project. 54 pages

[19]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

[20] Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, *20*(10), 3177–3190. https://doi.org/10.1111/gcb.12629

[21] Cairns, M. A., Brown, S., Helmer, E. H., Baumgardner, G. A., Cairns, M. A., Brown, S., … Baumgardner, G. A. (1997). Root Biomass Allocation in the World 's Upland Forests. Oecologia, 111(1), 1–11. http://doi.org/10.1007/s004420050201

[22] A copy of the database used to estimate carbon densities can be obtained by following this link: https://app.box.com/s/o5kwf7yu84mck4cnn4q0yghuq65zj5a9

Table 3-1. Allometric models used to estimate the above-ground biomass of the components recorded in three biomass inventories (NFI, ISNB and Technical Correction Inventory).

Component	National Forestry Inventory (NFI) and Additional 32 biomass sampling plots	Evaluating the Biomass and Carbon Content in Non-Forest Cover (ISNB)
Trees (DBH ≥ 5 cm) all species	$AGB = (0.0673 * (GE * dap^2 * H_t)^{0.976})$ [23] Pantropical	
Trees of (2 > DBH < 5 cm) all species	$\ln(AGB) = -9.37673 + 2.30119 \ln(dap) + 0.30297 \ln (H_t)$[24] Petén, Guatemala	
Trees of P. occidentalis and P. caribaea. (>2 cm DBH)	$\ln(AGB) = 1.17 + 2.119 * \ln (dap)$[25] Dominican Republic	*Not applicable*
Coffee crop - Coffea arabica	$\ln (AGB) = -2.39287 + 0.95285 * LN(dap) + 1.2693 * LN(H_t)$[26] *(dap 0,3 - 7,5 cm; HT 0.31 - 3.40 m)*	$\log (AGB) = -1.181 + 1.991 * log(d15))$[27] Matagalpa, Nicaragua
Other crops: Cocoa - Theobroma cacao; Avocado - Persea americana; Guava - Psidium guajaba; Seville orange - Citrus aurantium, C. Sinensis; Mango - Mangifera indica.	*Not applicable*	$\log (AGB) = -1.11 + 2.64 * Log(dap)$[28] Talamanca, Costa Rica
Coconut - Cocos nucifera	*Not applicable*	$\log(AGB) = 6.8414 * dap^{2.086} + 2.7340 * dap^{2.1837} + 2.7402 * dap^{1.9408}$ [29] Costa Rica

TerraPulse developed annual forest cover maps based on the canopy cover and probability of change in forest cover from one year to another. This information offers long-term and consistent mapping and monitoring of forest cover. It allows the retrieval of historical reference scenarios from the satellite records and the detection of deforestation, degradation, and growth over time. Based on FC maps, a forest cover change analysis was prepared considering only pixels with> 90% probability of having a forest cover higher than 30%, 60% and 85%. Subsequently, forest degradation classes and secondary forest cohorts were mapped into four categories: i. Intact Forest (>85% crown cover), ii. Degraded forest (60-85% crown cover), iii. Highly degraded forest (30-60% crown cover) and iv. Secondary Forest.

All forest inventory plots in forest and tree-shaded crops were classified into these four categories based on terraPulse data. By forest type and degradation class, carbon content was directly derived from the biomass sampling plots database (average and 90%CI). The mean annual carbon change in secondary forest and tree-shaded crops (tC/ha/yr.) was estimated by dividing the carbon change between non-forest and secondary forest land use by the time elapsed to reach the maximum biomass of the secondary forest type determined from the forest cover change maps.

Value applied:

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[23] Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. Global Change Biology, 20(10), 3177–3190. http://doi.org/10.1111/gcb.12629

[24] Arreaga, W. 2002. Almacenamiento de carbono en bosques con manejo forestal sostenible en la Reserva de Biosfera Maya, Petén, Guatemala. CATIE. Escuela de Postgrado. Tesis. 73p.

[25] Márquez (2000) citado por Brown (1996)

Table 3-2. Total forest biomass and non-forest land uses.

Land uses			Total Biomass (AGB+BGB+L+DW) $tC*ha^{-1}$	n
Permanent Forest	Pine	Intact forest	76.52 ± 7.4	25
		Degraded forest	47.79 ± 10.3	14
		Very degraded forest	44.19 ± 17.46	6
	Dry Broadleaf Forest	Intact forest	43.43 ± 7.85	6
		Degraded forest	42.63 ± 7.59	10
		Very degraded forest	35.35 ± 14.24	21
	Wet Broadleaf Forest	Intact forest	80.72 ± 11.75	75
		Degraded forest	50.91 ± 8.89	67
		Very degraded forest	39.38 ± 11.02	40
	Agricultural tree crops		64.93 ± 10.32	58
Secondary Forest	Pine	4-22yr	37.97 ± 23.15	9
		22-44yr	57.49 ± 14.33	14
	Dry Broadleaf Forest	4-22yr	27.62 ± 7	19
		22-44yr	30.2 ± 4.81	33
	Wet Broadleaf Forest	4-22yr	25.04 ± 4.24	39
		22-44yr	47.59 ± 8.69	59
Non-forest lands	Wet broadleaf shrubland		23.02 ± 10.67	17
	Dry broadleaf shrubland		18.54 ± 8.28	25
	Coconut		35.1 ± 10.97	12
	Grassland		9.68 ± 4.25	24
	Annual crops		14.85 ± 0.27[1]	-
	Human settlements		9.68 ± 4.25	24
				573

[1] Agricultural and Food Science Vol 18 (2009):347-365.

Table 3-3. Annual change in carbon stocks in biomass on land converted to forest

Type of Forest			Average of C Removal (AGB+BGB+L+DW) tg C/ha/yr	Error
Secondary Forest	Pine	8-22yr	1.29	49%
		22-44yr	1.09	22%
	Dry Broadleaf Forest	8-22yr	0.82	22%
		22-44yr	0.47	16%
	Wet Broadleaf Forest	4-22yr	0.70	17%
		22-44yr	0.86	17%
	Agricultural Tree Crops	4-22yr	1.75	22%
		22-44yr	1.13	17%

QA/QC procedures applied

NFI: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[30] and QA/QC[31] procedures to reduce non-sampling errors. Since the beginning of the planning phase, courses on basic forest inventory techniques

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[26] Suarez (2002)

[27] Segura, M.; Kanninen, M.; Suárez, D. 2006. Allometric models for estimating aboveground biomass of shade trees and coffee bushes grown together. Agroforestry Systems 68(2): 143-150

[28] Andrade, H.J.; Segura, M.; Somarriba, E.; Villalobos, M. 2008. Valoración biofísica y financiera de la fijación de carbono por uso del suelo en fincas cacaoteras indígenas de Talamanca, Costa Rica.

[29] Ares, A., Boniche, J., Quesada, J., Yost, R., Molina, E. and Smyth, T. 2002. Estimacion De Biomasa Por Metodos Alometricos, Nutrimentos Y Carbono En Plantaciones De Palmito En Costa Rica. Agronomia Costarricense, (26): 19-30.

[30] MARN-GIZ. 2014. Manual de Campo del Inventario Nacional Forestal de la República Dominicana. Unidad de Monitoreo Forestal. Programa REDD CCAD GIZ. Santo Domingo, R.D. 61p. https://app.box.com/s/e0jf1lb49wpbd2981f9iwvvo2gvbf0av

[31] MARN-GIZ. 2018. Protocolo para el control de calidad del Inventario Nacional Forestal de Republica Dominicana 2018. Unidad de Monitoreo Forestal y Unidad de Gestión del Proyecto de Preparación REDD+ de la República Dominicana. 9p. https://app.box.com/s/b9uoly8bpn5n4b8xivhtv2ob3z2gslub

were given to 68 forestry technicians, half of them MARN officials and the other half personnel who work outside the Ministry. Then, three-day training workshops were held on INF-RD Field Manual, with the participation of 97 technicians selected. Subsequently, the crews responsible for the field survey were designated and received rigorous training in the Field Manual and the Quality Control Manual.

ISNB: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[32] to reduce non-sampling errors. The crew members for the fieldwork received training for implementing inventory methodology and QA/QC procedures. The inventory methodology was explained, and field practices were carried out, including measurements and sampling exercises. During this training, the crew leaders were confirmed according to their abilities and capacities.

Technical Correction Inventory: The quality control procedures during the implementation of the survey of the 32 additional plots have been made following the NFI´s Field Manual and QA/QC procedures prepared by the Ministry of Environment and Natural Resources. The Forest Monitoring Unit of the Ministry has formed a quality control brigade that applied the QA/QC procedures in these additional plots; Likewise, the MARN QA/QC team and fieldwork crews were trained. Both teams worked together for two days, putting the inventory QA/QC protocol into practice.

FC maps and forest datasets: TerraPulse implemented the following QA/QC procedures for the preparation of FC maps[33]:

Image selection: Landsat 5, 7 and 8 Collection-2 level 1 images acquired between 1984 and 2021 were selected to provide time-series satellite multi-spectral representation of forest activity. The repeat cycle for each for each Landsat satellite is 16 days. The number of available Landsat images per WRS-2 tile for each year ranges from 22 to 66, where the data density increases with overlap in data acquisition between two satellites. For this project a total of 3008 scenes were used, which amounts to about 1.9 terabytes of data volume. The images to provide time-series satellite representation of forest were selected according to the following criteria:

- A maximum of four Landsat images within the growing season of each year were selected.
- The criteria for scene selection included cloud condition, sensor types, and season to minimize the effects of cloud contamination, forest phenology variation, and Landsat sensor quality (such as age of sensor and SLC-OFF issues).
- Landsat images with more than 80% cloud cover and images acquired during the leaf-off season were excluded from the selection as well. A score was calculated for each Landsat image to represent the suitability for estimating tree cover. Several metrics were considered in the calculation, including 1) percent of cloud cover 2) 100 * (Dt – D0/183), where Dt and D0 are the image acquisition date and July 1 of the year on Julian day, and 3) sensor type: where sensors were ranked based on their age and sensor issues based on the time window. 100 for OLI images, 50 for ETM+ images before 2004 and 10 for ETM images after 2004 (due to the SLC-off issues), and 30 for TM images.

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[32] MARN, 2017. Manual de Campo: Evaluación del contenido de biomasa y carbono en sistemas de No Bosque en la Republica Dominicana. Unidad de Monitoreo Forestal. Proyecto de Preparación de REDD+. 54p. https://app.box.com/s/056lacpm9rwyw2uh7a0aqz4a5yye9ol4

[33] Terrapulse, 2022. Appendix IV: Quality Assessment for TCC and forest datasets. In Technical Document: Estimation of Activity Data on Deforestation, Forest Degradation and Enhancement of Forest Carbon Stocks of Dominican Republic using Annual Time Series Analysis of Landsat data. 19p. https://app.box.com/s/hubmaeleboslxwuldev3gv5941dzcrbg

- The four images with the highest scores were selected as the final image set for a year. Up to 148 images could be selected for a WRS-2 tile for the entire Landsat record to ensure complete temporal coverage.

Image composite: After the scene selection step is completed, data is processed to TCC. Once TCC per Landsat tile is generated, a per-pixel compositing rule is applied to mosaic Landsat images with overlapping area for the country. This results in the most inclusive sample set, increasing the likeliness of filtering out anomalous estimates, such as contamination by residual clouds, SLC-OFF issues etc. The TCC estimates belonging to a year were then aggregated to produce the final annual estimate at each pixel for a given year, where the median operator was used to select the final pixel estimate from the selected TCC estimate group, and per pixel RMSE was calculated from the group to measure the uncertainty of the TCC estimate for the year.

Visual Assessment: After the completion of TCC mosaicking, the next step entails processing of time serial forest cover and change estimates using the globally calibrated TCC estimates. The globally calibrated TCC and forest activity assessment were then put on terraView (https://www.terrapulse.com/terraView/dr/) for the local partners at DR to visually assess the data for glaring and large-scale issues. No issues were reported and TCC did not need to be calibrated based on the validation exercise. The final TCC and post processed forest change datasets were visualized in an interactive map interface for assessment and were also validated using DR provided land cover maps. The high-resolution satellite images were also loaded into the interface as a reference during the examination. Although the high- resolution satellite map may not provide the exact representation of the forest at a given point in time of the evaluated TCC or forest changes, it could still provide the knowledge that is valuable for understanding the general pattern and distribution of forests in the region. Scene boundaries and large errors in the TCC process or forest change detection processes could be picked up by the visual examination by evaluating the spatial and temporal consistency as well as the consistency with the reference map. Additionally, internally the team at terraPulse used a time-series NDVI profile for selected regions to understand the phenological dynamics of the forests and forest activity.

Uncertainty associated with this parameter:

The uncertainty associated with Total Forest biomass and non-forest land uses and Annual change in carbon stocks in biomass on land converted to forest are listed above in Tables 3-4 and 3-5. Annual change in carbon stocks in biomass on land converted to the forest was calculated by combining uncertainties of land-use carbon densities before and after conversion, following IPCC approach 1 (addition and subtraction Eq 3.2).

Table 3-4: Uncertainty of total forest biomass and non-forest land uses

Land uses			Total Biomass (AGB+BGB+L+DW) tC*ha^{-1}	n
Permanent Forest	Pine	Intact forest	76.52 ± 7.4	25
		Degraded forest	47.79 ± 10.3	14
		Very degraded forest	44.19 ± 17.46	6
	Dry Broadleaf Forest	Intact forest	43.43 ± 7.85	6
		Degraded forest	42.63 ± 7.59	10
		Very degraded forest	35.35 ± 14.24	21
	Wet Broadleaf Forest	Intact forest	80.72 ± 11.75	75
		Degraded forest	50.91 ± 8.89	67
		Very degraded forest	39.38 ± 11.02	40
	Agricultural tree crops		64.93 ± 10.32	58
Secondary Forest	Pine	4-22yr	37.97 ± 23.15	9
		22-44yr	57.49 ± 14.33	14
	Dry Broadleaf Forest	4-22yr	27.62 ± 7	19
		22-44yr	30.2 ± 4.81	33
	Wet Broadleaf Forest	4-22yr	25.04 ± 4.24	39

		22-44yr	47.59 ± 8.69	59
Non-forest lands	Wet broadleaf shrubland		23.02 ± 10.67	17
	Dry broadleaf shrubland		18.54 ± 8.28	25
	Coconut		35.1 ± 10.97	12
	Grassland		9.68 ± 4.25	24
	Annual crops		14.85 ± 0.27[1]	-
	Human settlements		9.68 ± 4.25	24
				573

Table 3-5: Uncertainty of Annual change in carbon stocks in biomass on land converted to forest

Type of Forest			Error
Secondary Forest	Pine	8-22yr	49%
		22-44yr	22%
	Dry Broadleaf Forest	8-22yr	22%
		22-44yr	16%
	Wet Broadleaf Forest	4-22yr	17%
		22-44yr	17%
	Agricultural Tree Crops	4-22yr	22%
		22-44yr	17%

Any comment:

Total biomass was recalculated for each canopy cover category (>85%, 60-85%, and 30-60%) into each permanent forest type and forest cohort. Also, the ΔC_{RB_i} values were calculated from biomass sampling plots to replace the original estimates sourced scientific literature.

Parameters:	$A(j,i)_{RP}$; $A(j,i)_{LU}$, $\mathrm{A(j)}$ and $R(\mathrm{j,i})_{\mathrm{LU}}$
Description:	$A(j,i)_{RP}$: Area converted from forest type j to non-forest type i during the Reference Period, in hectares. **Equation 4.1**. $A(j,i)_{LU}$: Area converted from forest type j to non-forest type i of the Land Unit LU, in hectares. **Equation 5.1**. $\mathrm{A(j)}$: Area of Stable Forest type j, in hectares **Equation 5.5** $R(\mathrm{j,i})_{\mathrm{LU}}$: Area converted from non-forest type *j* to forest type *i* of the Land Unit LU, in hectares. **Equation 6.1**.
Data units:	Hectares
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Spatial level of data**: National **Sources of data**: Sampling-based estimates and associated uncertainties were used to calculate the activity data. Annual activity data for deforestation and forest regeneration were derived from the systematic sampling procedure (7,697 Permanent Sampling Units). **Methods:** Activity data estimate was made by applying the good practices and procedures identified by Olofsson et al. (2014) [34], GFOI (2016)[35] and GFOI (2021)[36]. The Dominican Republic MRV team prepared a Standard Operation Procedure for the sample-based REDD+ activity data estimation[37]. Although good practice recommends a stratified sampling to ensure a minimum number of plots in small strata, a systematic 2.5 x 2.5 km grid was used to generate activity data. Stratified sampling was not implemented due to the low accuracy of the non-permanent categories of the land-use change map for the period 2006-2015 (see Table A4.1) and because the use of independent surveys and temporary sample units does not enable the consistent and explicit tracking of land use spatially and temporally. The density of the systematic grid was estimated from the analysis of 474 systematic sampling points collected by Ovalles (2018)[38]. According to this analysis, with a sample size of 1942, it is possible to achieve a standard error of global precision of $S(\hat{o}) = 0.01$. However, DIARENA established a 2.5 x 2.5 km grid with 7,697 sampling points to reduce the standard error in uncommon transitions. ***Permanent Sample Units*** (PSU) of one hectare (100 x 100 meters) with a single evaluation point corresponding to the plot centroid was defined for the first phase[39]. PSUs were visually interpreted through time to ensure the ***temporal tracking of land use***. Land-use assessments were made for 2000, 2005, 2015, and 2018. The land-use class was interpreted with context and recorded for the individual pixel or point for t1 and t2. Using the land-use type at t1 and t2, the change class was determined for the pixel or point. Using single point Land-use change class

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[34] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

[35] GFOI. (2016). Integración de las observaciones por teledetección y terrestres para estimar las emisiones y absorciones de gases de efecto invernadero en los bosques. Métodos y orientación de la Iniciativa Mundial de Observación de los Bosques (Edición 2.). Roma: Organización de las Naciones Unidas para la Alimentación y la Agriculta.

[36] GFOI. (2021). Issues and good practices in sample-based area estimation.

[37] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

[38] Ovalles, P. (2018). Elaboración de mapa de Uso y Cobertura del Suelo 2015. Análisis de Cambios y Mapa de Deforestación en la República Dominicana. Informe Final. Santo Domingo, República Dominicana.

[39] A 7x7 points SU was planned to be used for a second phase to assess canopy cover only at permanent forest areas identified in the first phase. However, the country did not complete this analysis because canopy cover maps were used as the source of data to estimate the carbon fluxes in the permanent forest lands.

information, areas of change were calculated for the population. Interpreters also collected the ***transition year*** in the PSUs with a land-use change registered between assessments.

The Collect Earth Desktop (CED)[40] tool was used to perform the Multitemporal Visual Interpretation (MVI). Using Collect Earth Online[41] (CEO) was discarded. Unlike the CEO, CED provides access to high-resolution images from Google Earth, Bing Maps, and Planet, including medium (Sentinel) and low-resolution (Landsat) imagery from 2000 to 2018.

Value applied:

More than 400 activity data were estimated for the calculation of annual net emissions from deforestation and forest regeneration: Deforestation (96 land conversion types), SOC change transitions (160 Land Units), Permanent Forest types (5 types), and Forest regeneration (160 transitions). A summary of activity data values by forest type is shown in the below tables. All values can be consulted in the Activity Data tool (TF-OT, TF-TF, OT-TF, and SOC TF-OT sheets) [42].

Table 3-6: Deforested and Permanent Forest areas for the Reference Period 2006-2015.

Forest type	Deforested Area (ha) 2006-2015 (TF-OT) Total Biomass emissions	Permanent forest (ha) 2006-2015 (TF-TF)
Wet Broadleaf Forest	62,689	517,027
Dry Broadleaf Forest	31,655	358,753
Pine Forest	6,827	238,962
Agricultural Tree Crops	9,310	163,860
Mangroves	0	17,379

Table 3-7: Deforested Area (ha) (TF-OT) for SOC inherited emissions calculation*.

Forest type	1984-2000**	2001-2005	2006-2015
Wet Broadleaf Forest	269,375	16,758	49,654
Dry Broadleaf Forest	44,068	8,069	21,724
Pine Forest	0	4,345	3,724
Agricultural Tree Crops	0	621	8,069
Mangroves	0	0	0

**Activity data used to estimate SOC emissions does not include secondary forest loss area*

*** Deforested Area between 1984-2000 was obtained using the annual canopy cover maps 1984-2021 as reference data to define the year of the forest loss.*

Table 3-8: Forest Gain 2006-2015 (ha) (OT-TF) for inherited removals calculation.

Forest type	1984-2000*	2001-2005	2006-2015
Wet Broadleaf Forest	209,790	230,273	338,892
Dry Broadleaf Forest	103,654	122,895	153,929
Pine Forest	60,206	64,551	85,033

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

[41] https://collect.earth/

[42] DatosDeActivitidad-PR.xlsx tool can be accessed at the following link: https://app.box.com/s/wi8ayypl9bkpy8mpss43w4jgz2bp61yy

Agricultural Tree Crops	76,344	78,826	98,688
Mangroves	1,862	1,862	2,483

** Forest Gain Area between 1984-and 2000 was obtained using the annual canopy cover maps 1984-2021 as reference data to define the year of change to new forest areas.*

QA/QC procedures applied

The Dominican Republic MRV team prepared a Standard Operation Procedure (SOP) for the sample-based REDD+ activity data estimation[43]. This SOP includes a quality control and quality assurance (QA/QC) procedure and a visual interpretation decision tree for high-resolution and low-resolution imagery to ensure the analysts used the best imagery dataset during the photo-interpretation of the land-use class in the sampling point.

Analysts received training to calibrate the observations and make clear the procedures to collect accurate data. After completing the training, the analysts interpreted a sample of 50 points. An analysis of differences between analysts was made, and no significant differences (95% significance) were found between them. Thus, the consistency between analysts was ensured.

During the MVI process, a specialist with extensive experience supervised the work of the analysts. The supervisor did the quality control of the land use visual interpretations in two phases:

a. During the visual interpretation of the sampling points, the analysts had to make monthly deliveries of the evaluated points. The supervisor reviewed each monthly delivery to identify and correct errors and check transition consistency and the years of change registered.

b. Finally, according to QA/QC procedures, the minimum level of consistency between the analysts and the supervisor should be 90% on land-use interpretation. Once all sampling points were assessed, the supervisor randomly selected 100 plots per assessment (year) for consistency verification. The land use definition for the whole period (2000-2118) had 95% consistency between analysts and the supervisor (see table 3-7).

Table 3-9: General consistency between analysts and the supervisor on land-use interpretation.

Assessment	Points interpreted consistently	n	%
2000	82	97	85%
2006	82	95	86%
2015	84	91	92%
2018	90	96	94%
Total	360	379	95%

Uncertainty associated with this parameter:

Table 3-10: Estimation error of Deforested and Permanent Forest areas for the Reference Period 2006-2015.

Forest type	**Estimation error of Deforested Areas 2006-2015 (TF-OT) Total Biomass emissions**	**Estimation error of Permanent Forest areas 2006-2015 (TF-TF)**

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[43] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

Wet Broadleaf Forest	20%	6%
Dry Broadleaf Forest	28%	8%
Pine Forest	66%	10%
Agricultural Tree Crops	55%	12%
Mangroves	NA	39%

Table 3-11: Estimation error of Deforested Area (ha) (TF-OT) for SOC inherited emissions calculation.

Forest type	1984-2000	2001-2005	2006-2015
Wet Broadleaf Forest	9%	39%	22%
Dry Broadleaf Forest	24%	60%	34%
Pine Forest	NA	89%	100%
Agricultural Tree Crops	NA	1271%	60%
Mangroves	NA	NA	NA

Table 3-12: Estimation error of Forest Gain Area (ha) (OT-TF) for inherited removals calculation.

Forest type	1984-2000*	2001-2005	2006-2015
Wet Broadleaf Forest	11%	10%	8%
Dry Broadleaf Forest	16%	14%	12%
Pine Forest	21%	19%	17%
Agricultural Tree Crops	18%	17%	16%
Mangroves	184%	184%	139%

Any comment:

Activity data estimate for reference and monitoring periods is based on land-use tracking from 2000 to 2024. The activity data includes two data sets: i. Reference Level consists of three subperiods 2000-2005, 2005-2015, and 2015-2018; ii. Monitoring Periods consist of tree subperiods, 2018-2021, 2021-2023 and 2023-2024. The 2018 measurement is common to both activity data sets (Reference Level and Monitoring Periods), 2018 was reassessed in the monitoring period. Once the visual assessment was completed, the 2018 land-use of 985 points (13% of the 7,697 sampling points in the systematic grid), were not consistent between the two data sets. The availability of new high-resolution images in the 2022 measurement improved the interpretation of land use in the Monitoring Period dataset. The updated 2018 measurement affected the transitions and land-use assessments made in the Reference Period dataset. Therefore, it was necessary to revise the land-use interpretations and the transitions of the 985 inconsistent points in the two data sets (2000-2018 and 2018-2024).

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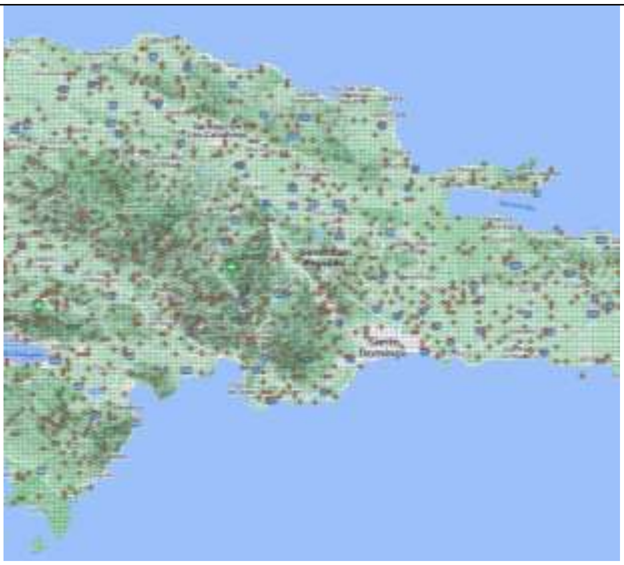

Figure 3-1: Spatial distribution of 985 inconsistent points.

Parameter:	$\mathrm{Deg(j,i)_{RP}}$:
Description:	$\mathrm{Deg(j,i)_{RP}}$: Area converted from forest with canopy cover j to forest with canopy cover i during the Reference Period, in hectares per year. **Equation 4.3.**
Data unit:	Hectares
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Spatial level of data**: National **Sources of data**: Sampling-based estimates and associated uncertainties were used to calculate the activity data. Forest cover annual maps were used as reference information to determine the canopy cover categories for each sampling point. **Methods:** Annual activity data for degradation and carbon enhancement in permanent forest were derived from the systematic sampling procedure (7,697 Permanent Sampling Units) and Forest Cover (FC) annual maps. FC maps were used to determine the canopy cover class or secondary forest's age of all biomass inventory plots used to estimate carbon content by forest type and degradation class. With FC maps information was possible to assign each Biomass plot the canopy cover class 30-60%, 60-85%, and >85%. Canopy cover activity data (degradation/enhancement) was also estimated from canopy cover maps. FC data was used to estimate activity data for three reasons: a. The FC maps provide a consistent stratification of biomass plots for different forest types, canopy density categories, and forest age, b. The use of TCC maps to calculate changes in canopy cover ensures consistency between activity data and carbon densities, and c. With this approach, it was possible to include the bias in estimating the canopy cover of the FC maps. The bias was estimated by comparing the values of the TCC map concerning the visual interpretation of the percentage of canopy cover. Sample-based area estimation method was used to calculate activity data. Forest cover and its probability were extracted from FC maps for each sampling point in a systematic grid. One pixel was assigned to a canopy cover class if the probability of having a canopy cover is higher than 90%. A denser sampling grid was used, 2.5 x 2.5 km, instead of the original 5 x 5 km grid. This 2.5 x 2.5 km sampling grid is also used to visually assess land-use change over high-res imagery. Tree-canopy cover was estimated through an automatic learning algorithm based on a model f of remotely sensed variables *X* in any location *I*, $\widehat{C_\iota} = f(X; \hat{\beta}) + \varepsilon$. $\widehat{C_\iota}$ is the percentage of a pixel (*i*)'s area covered by trees; β is a set of empirically estimated parameters; ε is residual error or uncertainty; and *X* is a set of measurements of surface reflectance, derived indices (NDVI, NDWI, and MNDWI) and metadata describing acquisition and sensor characteristics (Sexton et al.2013)[44]. This algorithm was applied to the stack of Landsat images available for each year, to prepare the Dominican Republic annual canopy cover wall-to-wall raster maps from 1984 to 2021, with 30*30 m resolution; each pixel has a canopy cover value and the probability estimate. Further information on the preparation methods of canopy cover maps is detailed in Consultancy Report[45].

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[44] Sexton, JO, X-P Song, M Feng, P Noojipady, A Anand, C Huang, D-H Kim, KM Collins, S Channan, C DiMiceli & JR Townshend. 2013a. Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS continuous fields and lidar-based estimates of error. International Journal of Digital Earth 6: 427-448

[45] terraPulse, 2018. Estimation of Activity Data on Deforestation, Forest Degradation and Enhancement of Forest Carbon Stocks of Dominican Republic using Annual Time Series Analysis of Landsat data. Technical Document. 12 p. https://app.box.com/s/0i7wl8wss4l40mjl3299gfwpo4i7djoz

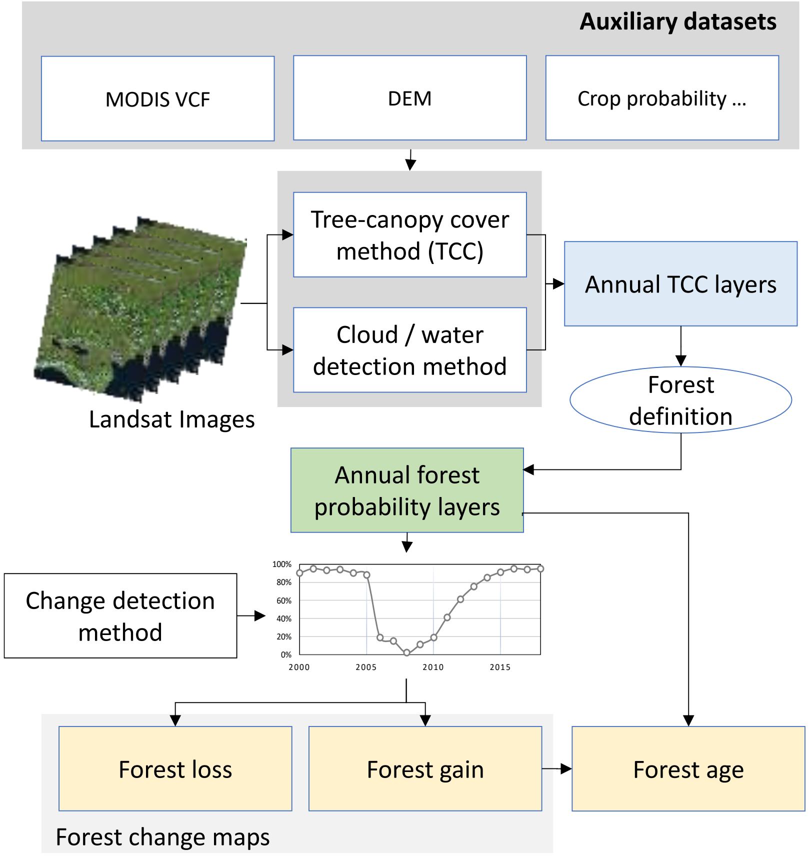

Figure 3-2. Estimation of percent-tree cover as a standard normal distribution of cover (mean) and uncertainty (standard deviation) in each pixel (Sexton et al. 2015)[46].

Value applied:

More than 48 activity data were estimated for the annual emission of degradation and carbon enhancement in permanent forest. A summary of activity data values by forest type is shown in the following table. All values can be consulted in the Activity Data tool (TF-TF sheets) [47].

Table 3-13: Canopy cover transition areas in permanent forest lands - 2006-2015

Canopy cover transition in permanent forest lands		Area 2006-2015 (ha)
Wet Broadleaf Forest	Enhancement	131,584
	Degradation	42,206

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[46] Sexton, JO, P Noojipady, A Anand, X-P Song, C Huang, SM McMahon, M Feng, S Channan & JR Townshend. 2015. A model for the propagation of uncertainty from continuous estimates of tree cover to categorical forest cover and change. Remote Sensing of Environment 156: 418-425

[47] DatosDeActivitidad-PR.xlsx tool can be accessed at the following link: https://app.box.com/s/wi8ayypl9bkpy8mpss43w4jgz2bp61yy

Dry Broadleaf Forest	Enhancement	22,965
	Degradation	27,931
Pine Forest	Enhancement	37,862
	Degradation	22,345
Agricultural Tree Crops	Native forest	621
Native forest	Agricultural Tree Crops	1,862
Mangroves	Enhancement	6,207
	Degradation	1,241

QA/QC procedures applied

Permanent forest areas estimate: The same QA/QC procedures for deforestation and regeneration were applied to the estimate of degradation activity data. In this case, QA/QC procedures were focused on the interpretation of permanent forest areas.

FC maps and forest datasets: TerraPulse implemented the following QA/QC procedures for the preparation of FC maps[48]:

Image selection: Landsat 5, 7 and 8 Collection-2 level 1 images acquired between 1984 and 2021 were selected to provide time-series satellite multi-spectral representation of forest activity. The repeat cycle for each for each Landsat satellite is 16 days. The number of available Landsat images per WRS-2 tile for each year ranges from 22 to 66, where the data density increases with overlap in data acquisition between two satellites. For this project a total of 3008 scenes were used, which amounts to about 1.9 terabytes of data volume. The images to provide time-series satellite representation of forest were selected according to the following criteria:

- A maximum of four Landsat images within the growing season of each year were selected.
- The criteria for scene selection included cloud condition, sensor types, and season to minimize the effects of cloud contamination, forest phenology variation, and Landsat sensor quality (such as age of sensor and SLC-OFF issues).
- Landsat images with more than 80% cloud cover and images acquired during the leaf-off season were excluded from the selection as well. A score was calculated for each Landsat image to represent the suitability for estimating tree cover. Several metrics were considered in the calculation, including 1) percent of cloud cover 2) 100 * (Dt – D0/183), where Dt and D0 are the image acquisition date and July 1 of the year on Julian day, and 3) sensor type: where sensors were ranked based on their age and sensor issues based on the time window. 100 for OLI images, 50 for ETM+ images before 2004 and 10 for ETM images after 2004 (due to the SLC-off issues), and 30 for TM images.

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[48] Terrapulse, 2022. Appendix IV: Quality Assessment for TCC and forest datasets. In Technical Document: Estimation of Activity Data on Deforestation, Forest Degradation and Enhancement of Forest Carbon Stocks of Dominican Republic using Annual Time Series Analysis of Landsat data. 19p. https://app.box.com/s/hubmaeleboslxwuldev3gv5941dzcrbg

	- The four images with the highest scores were selected as the final image set for a year. Up to 148 images could be selected for a WRS-2 tile for the entire Landsat record to ensure complete temporal coverage. **Image composite**: After the scene selection step is completed, data is processed to TCC. Once TCC per Landsat tile is generated, a per-pixel compositing rule is applied to mosaic Landsat images with overlapping area for the country. This results in the most inclusive sample set, increasing the likeliness of filtering out anomalous estimates, such as contamination by residual clouds, SLC-OFF issues etc. The TCC estimates belonging to a year were then aggregated to produce the final annual estimate at each pixel for a given year, where the median operator was used to select the final pixel estimate from the selected TCC estimate group, and per pixel RMSE was calculated from the group to measure the uncertainty of the TCC estimate for the year. **Visual Assessment**: After the completion of TCC mosaicking, the next step entails processing of time serial forest cover and change estimates using the globally calibrated TCC estimates. The globally calibrated TCC and forest activity assessment were then put on terraView (https://www.terrapulse.com/terraView/dr/) for the local partners at DR to visually assess the data for glaring and large-scale issues. No issues were reported and TCC did not need to be calibrated based on the validation exercise. The final TCC and post processed forest change datasets were visualized in an interactive map interface for assessment and were also validated using DR provided land cover maps. The high-resolution satellite images were also loaded into the interface as a reference during the examination. Although the high- resolution satellite map may not provide the exact representation of the forest at a given point in time of the evaluated TCC or forest changes, it could still provide the knowledge that is valuable for understanding the general pattern and distribution of forests in the region. Scene boundaries and large errors in the TCC process or forest change detection processes could be picked up by the visual examination by evaluating the spatial and temporal consistency as well as the consistency with the reference map. Additionally, internally the team at terraPulse used a time-series NDVI profile for selected regions to understand the phenological dynamics of the forests and forest activity.
Uncertainty associated with this parameter:	Canopy cover estimates in FC maps are considered biased. The bias was assessed by comparing the map canopy cover estimates with tree cover reference data. Canopy cover estimate is based on the visual interpretation of high-resolution imagery using Collect Earth Desktop. DIARENA analysts collected tree canopy cover with a 1 ha sampling plot (with 3 x 3 subpoint inside) systematically distributed in permanent forest land with a 5 x 5 km sampling grid. Canopy cover reference data collected by the Dominican Republic team was overlaid with coincident terraPulse canopy cover estimates. The reference data and terraPulse estimates were subtracted to calculate the bias of each terraPulse data point. The estimated bias of the canopy cover in Forest Cover maps is 4.34%, with a standard deviation of 61.691. The probability distribution function of the bias was fitted with the scipy open-source python package (https://scipy.org), obtaining a normal distribution of the canopy cover bias. Maximum Likelihood was used to estimate the mean and variance parameters. The uncertainty

determination of the total sampling point assigned to each canopy cover change class was made with the bootstrap method, with 1000 simulations based on the bias estimate[49].

The sampling error of estimating the areas of the canopy cover class change was also calculated (table below). Both uncertainties are included in error propagation made with Monte Carlo analysis for the uncertainty estimate of the reference emission level.

Table 3-14: Sampling error of canopy cover transition areas in permanent forest lands -2006-2015

Canopy cover transition in permanent forest lands		Area 2006-2015 (ha)
Wet Broadleaf Forest	Enhancement	13%
	Degradation	24%
Dry Broadleaf Forest	Enhancement	33%
	Degradation	30%
Pine Forest	Enhancement	26%
	Degradation	34%
Agricultural Tree Crops	Native forest	1271%
Native forest	Agricultural Tree Crops	184%
Mangroves	Enhancement	70%
	Degradation	304%

Any comment:

There are no comments.

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[49] The Excel tool used to estimate the canopy cover change category determination uncertainty by the bootstrap method can be accessed at the following link: https://app.box.com/s/ex2otzvkk4u32armla8rory8as9iu7tj

Parameter:	$SOC_j, SOC_i\ ,\ S(j,i)$
Description:	SOC_j : Soil Organic Carbon of forest type j before conversion **Equation 5.2** SOC_i: Soil Organic Carbon of non-forest type i after conversion **Equation 5.2** $S(j,i)$: Soil Organic Carbon Linear decreasing rate for transition j to I **Equation 5.2**
Data unit:	$SOC_j\ and\ SOC_i$ tons of C per ha $S(j,i)$ tons of C per ha per year
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Spatial level of data**: National **Sources of data**: SOC Estimate for each forest type and non-forest classes is based on the Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015 (**Technical Correction Inventory**) [50]. **Methods**: For the determination of the organic carbon balance of the soil after deforestation in the main types of soil, 260 plots were established in paired forest – non-forest plots. Sampling Plots were located ensuring at least five paired plots in each of the main transitions by soil type that add up to 80% of the area of change observed during the reference period (2006-15). The following samples were obtained in each of these plots: a. SOC sample 0-15 cm, b. SOC sample 15-30 cm, c. Unaltered sample Bulk Density 0-15 cm and d. Unaltered samples' Bulk Density of 15 - 30 cm. 520 samples (altered samples) were taken for laboratory analysis to determine the SOC. Likewise, 520 unaltered samples were analyzed to determine the Bulk Density and the volumetric fraction of coarse fragments[51]. Organic Carbon Concentration (OCC) was estimated with the Walkley-Black colorimetric method under the NVN 575 standard. Bulk density (BD) was determined by relating the soil sample's dry weight (105˚C) and the soil's volume. The soil organic carbon stock was calculated as the product of organic carbon concentration (OCC), bulk density (BD), and the proportion of the volumetric fraction of coarse fragments (S). $\mathrm{SOC} = \mathrm{OCC}\ \times \mathrm{BD} \times \mathrm{D}(1 - \mathrm{S})$. OCC is in g x 100 g^{-1}, BD is in g x cm^{-3}, D is the thickness of the layer (30 cm) and S is in g x g^{-1}. The Soil Organic Carbon Linear decreasing rate was calculated based on the estimate of SOC before and after conversion with Equation 2.25 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. Average SOC before and after conversion was estimated by forest types. The determination of the year of land-use conversion in the SOC sampling plot is based on an analysis of time series of high-resolution satellite images and Landsat imagery repositories available on the Google Earth platform. The average SOC after conversion includes grasslands, annual crops, and shrublands. Only samples with a SOC decrease after conversion was considered (64 samples)[52].

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[50]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

[51] A copy of the original database of SOC before and after conversion can be accessed at the following link: https://app.box.com/s/a2ic2wqvrqxg36d3633poe8ziv1zdj8s

[52] A copy of the final database used to estimate average SOC before and after conversion can be accessed at the following link: https://app.box.com/s/07poveih5s7ifxjcryv7ciaqu20weq03

Value applied:

Table 3-15: Average SOC before and after conversion and SOC linear decreasing rate by forest types

Forest type	Soil Organic Carbon by forest type before conversion tC*ha^{-1}	Soil Organic Carbon by forest type after conversion tC*ha^{-1}	Soil Organic Carbon Linear decreasing rate tC*ha^{-1}*yr^{-1}	Number of sampling plots
Wet Broadleaf Forest	23.10	11.31	0.48	34
Dry Broadleaf Forest	34.37	22.45	0.67	15
Pine Forest	29.26	12.02	1.18	10
Agricultural Tree Crops	24.49	10.85	0.45	5

Values for Wet Broadleaf Forest were used for Mangrove transitions.

QA/QC procedures applied

The QA/QC procedure applied for the collection of SOC samples includes the following:

a. Field check that the sampling site corresponds to the type of transition to be sampled.

b. A field manual was prepared and implemented to collect 200 g soil samples at a depth of 0 to 15 cm and from 15 to 30 cm deep, as well as for the bulk density sample.

c. All samples were labeled and stored.

For further detail on QA/QC procedures, see section 3.2 of the consultancy report of the Technical Correction Inventory[53].

Uncertainty associated with this parameter:

Estimation error of SOC linear decreasing was calculated combining uncertainties of average SOC before and after conversion, following IPCC approach 1 (addition and subtraction Eq 3.2)

Table 3-16: Estimation error of Average SOC before and after conversion and SOC linear decreasing rate by forest types

Forest type	Estimation error of Soil Organic Carbon by forest type before conversion	Estimation error of Soil Organic Carbon by forest type after conversion	Estimation error of Soil Organic Carbon Linear decreasing rate (*)
Wet Broadleaf Forest	28%	30%	21%
Dry Broadleaf Forest	25%	28%	19%
Pine Forest	62%	34%	45%
Agricultural Tree Crops	73%	46%	52%

Any comment:

There are no comments.

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[53]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

3.2 Monitored Data and Parameters

Parameters:	$A(j,i)_{MP}$; $A(j,i)_{LU}$, A(j) and $R(\mathrm{j,i})_{\mathrm{LU}}$
Description:	$A(j,i)_{MP}$: Area converted from forest type j to non-forest type i during the Reference Period, in hectares. **Equation 9.1**. $A(j,i)_{LU}$: Area converted from forest type j to non-forest type i of the Land Unit LU, in hectares. **Equation 5.1**. A(j): Area of Stable Forest type j, in hectares **Equation 5.5** $R(\mathrm{j,i})_{\mathrm{LU}}$: Area converted from non-forest type *j* to forest type *i* of the Land Unit LU, in hectares. **Equation 6.1**.
Data units:	Hectares
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Spatial level of data**: National **Sources of data**: Sampling-based estimates and associated uncertainties were used to calculate the activity data. Annual activity data for deforestation and forest regeneration were derived from the systematic sampling procedure (7,697 Permanent Sampling Units). **Methods:** Activity data estimate was made by applying the good practices and procedures identified by Olofsson et al. (2014) [54], GFOI (2016)[55] and GFOI (2021)[56]. The Dominican Republic MRV team prepared a Standard Operation Procedure for the sample-based REDD+ activity data estimation[57]. The same methods used to generate activity data for the reference level are used for the monitoring period, including the systematic 2.5 x 2.5 km grid, and the use of ***Permanent Sample Units*** (PSU) of one hectare (100 x 100 meters) with a single evaluation point corresponding to the plot centroid. PSUs are visually interpreted through time to ensure the ***temporal tracking of land use***. For the monitoring periods, land-use assessments are made for **2018, 2021, 2023, and 2024**. The 2018 assessment has the same land-use interpretation collected in the time series analysis for the reference level estimation (2000-2018). The Collect Earth Desktop (CED)[58] tool is used to perform the Multitemporal Visual Interpretation (MVI) during the monitoring period.
Value applied:	More than 400 activity data are estimated for the calculation of annual net emissions from deforestation and forest regeneration: Deforestation (96 land conversion types), SOC change transitions (160 Land Units), Permanent Forest types (5 types), and Forest regeneration (160 transitions). A summary of activity data values

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[54] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

[55] GFOI. (2016). Integración de las observaciones por teledetección y terrestres para estimar las emisiones y absorciones de gases de efecto invernadero en los bosques. Métodos y orientación de la Iniciativa Mundial de Observación de los Bosques (Edición 2.). Roma: Organización de las Naciones Unidas para la Alimentación y la Agriculta.

[56] GFOI. (2021). Issues and good practices in sample-based area estimation.

[57] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

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

by forest type is shown in the below tables. All values can be consulted in the Activity Data tool (TF-OT, TF-TF, OT-TF, and SOC TF-OT sheets)[59].

Table 3-17: Deforested and Permanent Forest areas for the Reference Period 2006-2015.

Forest type	Deforested Area (ha) 2019-2021 (TF-OT) Total Biomass emissions	Permanent forest (ha) 2021 (TF-TF)
Wet Broadleaf Forest	28,551	495,924
Dry Broadleaf Forest	14,276	341,374
Pine Forest	1,862	237,100
Agricultural Tree Crops	5,586	158,894
Mangroves	0	19,241

Table 3-18: Deforested Area (ha) (TF-OT) for SOC inherited emissions calculation*.

Forest type	1984-2000**	2001-2005	2006-2015	2016-2018	2019-2021
Wet Broadleaf Forest	269,375	16,758	49,654	10,552	11,172
Dry Broadleaf Forest	44,068	8,069	21,724	8,069	9,310
Pine Forest	0	4,345	3,724	0	1,241
Agricultural Tree Crops	0	621	8,069	2,483	2,483
Mangroves	0	0	0	0	0

**Activity data used to estimate SOC emissions does not include secondary forest loss area*
*** Deforested Area between 1984-2000 was obtained using the annual canopy cover maps 1984-2021 as reference data to define the year of the forest loss.*

Table 3-19: Forest Gain 2006-2015 (ha) (OT-TF) for inherited removals calculation.

Forest type	1984-2000*	2001-2005	2006-2015	2016-2018	2019-2021
Wet Broadleaf Forest	209,790	230,273	338,892	373,029	376,753
Dry Broadleaf Forest	103,654	122,895	153,929	165,101	172,549
Pine Forest	60,206	64,551	85,033	89,999	89,999
Agricultural Tree Crops	76,344	78,826	98,688	101,792	101,792
Mangroves	1,862	1,862	2,483	2,483	3,103

** Forest Gain Area between 1984-and 2000 was obtained using the annual canopy cover maps 1984-2021 as reference data to define the year of change to new forest areas.*

QA/QC procedures applied

The same SOP for the sample-based REDD+ activity data estimation[60] was used to collect the land-use change for the 2019-2021 monitoring period. The same analysts that interpreted land use for the reference period

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[59] DatosDeActivitidad-PM.xlsx tool can be accessed at the following link: https://app.box.com/s/h2dxm1qvdcir4ltxa575h32spev3kszg

[60] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

performed the land-use change assessment for the 2019-2021 monitoring period. For this reason, it was not necessary to provide additional training to ensure consistency between analysts. During the MVI process, a specialist with extensive experience supervised the work of the analysts. The supervisor reviewed weekly deliveries of photo-interpreted points. This review focused on identifying and correcting errors and checking transition consistency and the years of change registered.

Uncertainty associated with this parameter:

The uncertainty associated with Total Forest biomass and non-forest land uses and Annual change in carbon stocks in biomass on land converted to forest are listed above in Tables 3-20, 3-20 and 3-2. The Probability Distribution Function has been fitted for each Land-use carbon density class. Annual change in carbon stocks in biomass on land converted to the forest was calculated by combining uncertainties of land-use carbon densities before and after conversion, following IPCC approach 1 (addition and subtraction Eq 3.2).

Table 3-20: Estimation error of Deforested and Permanent Forest areas for the Reference Period 2006-2015.

Forest type	Estimation error of Deforested Areas 2019-2021 (TF-OT) Total Biomass emissions	Estimation error of Permanent Forest areas 2021 (TF-TF)
Wet Broadleaf Forest	30%	7%
Dry Broadleaf Forest	43%	8%
Pine Forest	184%	10%
Agricultural Tree Crops	75%	12%
Mangroves	NA	37%

Table 3-21: Estimation error of Deforested Area (ha) (TF-OT) for SOC inherited emissions calculation.

Forest type	1984-2000	2001-2005	2006-2015	2016-2018	2019-2021
Wet Broadleaf Forest	9%	39%	22%	51%	49%
Dry Broadleaf Forest	24%	60%	34%	60%	55%
Pine Forest	NA	89%	100%	NA	304%
Agricultural Tree Crops	NA	1271%	60%	139%	139%
Mangroves	NA	NA	NA	NA	NA

Table 3-22: Estimation error of Forest Gain Area (ha) (OT-TF) for inherited removals calculation.

Forest type	1984-2000*	2001-2005	2006-2015	2016-2018	2019-2021
Wet Broadleaf Forest	11%	10%	8%	8%	8%
Dry Broadleaf Forest	16%	14%	12%	12%	12%
Pine Forest	21%	19%	17%	16%	16%
Agricultural Tree Crops	18%	17%	16%	15%	15%
Mangroves	184%	184%	139%	139%	115%

Any comment:

Activity data estimate for reference and monitoring periods is based on land-use tracking from 2000 to 2024. The activity data includes two data sets: i. Reference Level consists of three subperiods 2000-2005, 2005-2015, and

	2015-2018; ii. Monitoring Periods consist of tree subperiods, 2018-2021, 2021-2023 and 2023-2024. The 2018 measurement is common to both activity data sets (Reference Level and Monitoring Periods), 2018 was reassessed in the monitoring period. Once the visual assessment was completed, the 2018 land-use of 985 points (13% of the 7,697 sampling points in the systematic grid), were not consistent between the two data sets. The availability of new high-resolution images in the 2022 measurement improved the interpretation of land use in the Monitoring Period dataset. The updated 2018 measurement affected the transitions and land-use assessments made in the Reference Period dataset. Therefore, it was necessary to revise the land-use interpretations and the transitions of the 985 inconsistent points in the two data sets (2000-2018 and 2018-2024).

Parameter:	$\mathrm{Deg(j,i)_{MP}}$:
Description:	$\mathrm{Deg(j,i)_{MP}}$: Area converted from forest with canopy cover j to forest with canopy cover i during the Monitoring Period, in hectares per year. **Equation 9.3.**
Data unit:	Hectares
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Spatial level of data**: National **Sources of data**: Sampling-based estimates and associated uncertainties were used to calculate the activity data. Forest cover annual maps were used as reference information to determine the canopy cover categories for each sampling point. **Methods:** Annual activity data for degradation and carbon enhancement in permanent forest were derived from the systematic sampling procedure (7,697 Permanent Sampling Units) and Forest Cover (FC) annual maps. Activity data estimate was made by applying the good practices and procedures identified by Olofsson et al. (2014) [61], GFOI (2016)[62] and GFOI (2021)[63]. The Dominican Republic MRV team prepared a Standard Operation Procedure for the sample-based REDD+ activity data estimation[64]. FC maps provide a more robust determination of Canopy Cover than high-resolution imagery interpretation. Therefore, forest cover and its probability were extracted from FC maps for each sampling point located in a permanent forest in the systematic grid to assign the canopy cover class 30-60%, 60-85%, and >85% for the later analysis of canopy cover change. One pixel was assigned to a canopy cover class if the probability of having a canopy cover above the threshold C was higher than 90%. Tree-canopy cover was estimated through an automatic learning algorithm based on a model f of remotely sensed variables X in any location I, $\widehat{C_{\iota}} = f(X;\hat{\beta}) + \varepsilon$. $\widehat{C_{\iota}}$ is the percentage of a pixel

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[61] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

[62] GFOI. (2016). Integración de las observaciones por teledetección y terrestres para estimar las emisiones y absorciones de gases de efecto invernadero en los bosques. Métodos y orientación de la Iniciativa Mundial de Observación de los Bosques (Edición 2.). Roma: Organización de las Naciones Unidas para la Alimentación y la Agriculta.

[63] GFOI. (2021). Issues and good practices in sample-based area estimation.

[64] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

	(*i*)'s area covered by trees; β is a set of empirically estimated parameters; ε is residual error or uncertainty; and *X* is a set of measurements of surface reflectance, derived indices (NDVI, NDWI, and MNDWI) and metadata describing acquisition and sensor characteristics (Sexton et al.2013)[65]. This algorithm was applied to the stack of Landsat images available for each year, to prepare the Dominican Republic annual canopy cover wall-to-wall raster maps from 1984 to 2021, with 30*30 m resolution; each pixel has a canopy cover value and the probability estimate. Further information on the preparation methods of canopy cover maps is detailed in Consultancy Report[66].

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[65] Sexton, JO, X-P Song, M Feng, P Noojipady, A Anand, C Huang, D-H Kim, KM Collins, S Channan, C DiMiceli & JR Townshend. 2013a. Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS continuous fields and lidar-based estimates of error. International Journal of Digital Earth 6: 427-448

[66] terraPulse, 2018. Estimation of Activity Data on Deforestation, Forest Degradation and Enhancement of Forest Carbon Stocks of Dominican Republic using Annual Time Series Analysis of Landsat data. Technical Document. 12 p. https://app.box.com/s/0i7wl8wss4l40mjl3299gfwpo4i7djoz

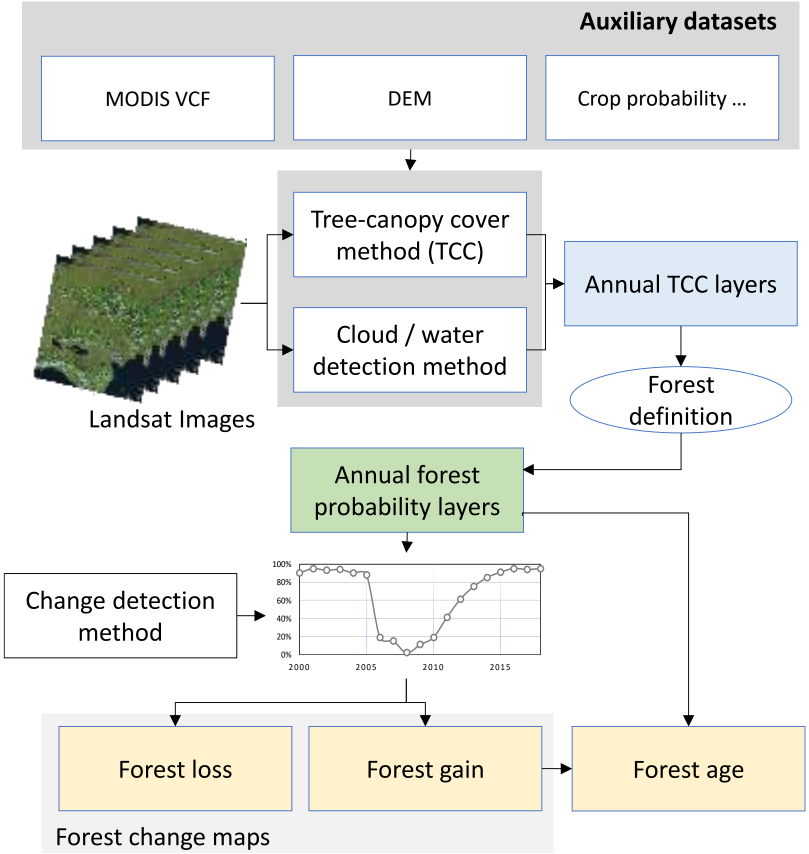

Figure 3-3. Estimation of percent-tree cover as a standard normal distribution of cover (mean) and uncertainty (standard deviation) in each pixel (Sexton et al. 2015)[67].

Value applied:

More than 48 activity data were estimated for the annual emission of degradation and carbon enhancement in permanent forest. A summary of activity data values by forest type is shown in the following table. All values can be consulted in the Activity Data tool (TF-TF sheet)[68].

Table 3-23: Canopy cover transition areas in permanent forest lands - 2019-2021

Canopy cover transition in permanent forest lands		Area 2021 (ha)
Wet Broadleaf Forest	Enhancement	57,103
	Degradation	52,758
Dry Broadleaf Forest	Enhancement	31,655

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[67] Sexton, JO, P Noojipady, A Anand, X-P Song, C Huang, SM McMahon, M Feng, S Channan & JR Townshend. 2015. A model for the propagation of uncertainty from continuous estimates of tree cover to categorical forest cover and change. Remote Sensing of Environment 156: 418-425

[68] DatosDeActivitidad-PM.xlsx tool can be accessed at the following link: https://app.box.com/s/h2dxm1qvdcir4ltxa575h32spev3kszg

	Degradation	10,552
Pine Forest	Enhancement	18,000
	Degradation	10,552
Agricultural Tree Crops	Native forest	-
Native forest	Agricultural Tree Crops	621
Mangroves	Enhancement	2,483
	Degradation	-

QA/QC procedures applied

Permanent forest areas estimate: The same QA/QC procedures for deforestation and regeneration were applied to the estimate of degradation activity data. In this case, QA/QC procedures were focused on the interpretation of permanent forest areas.

FC maps and forest datasets: TerraPulse implemented the following QA/QC procedures for the preparation of FC maps[69]:

Image selection: Landsat 5, 7 and 8 Collection-2 level 1 images acquired between 1984 and 2021 were selected to provide time-series satellite multi-spectral representation of forest activity. The repeat cycle for each for each Landsat satellite is 16 days. The number of available Landsat images per WRS-2 tile for each year ranges from 22 to 66, where the data density increases with overlap in data acquisition between two satellites. For this project a total of 3008 scenes were used, which amounts to about 1.9 terabytes of data volume. The images to provide time-series satellite representation of forest were selected according to the following criteria:

- A maximum of four Landsat images within the growing season of each year were selected.
- The criteria for scene selection included cloud condition, sensor types, and season to minimize the effects of cloud contamination, forest phenology variation, and Landsat sensor quality (such as age of sensor and SLC-OFF issues).
- Landsat images with more than 80% cloud cover and images acquired during the leaf-off season were excluded from the selection as well. A score was calculated for each Landsat image to represent the suitability for estimating tree cover. Several metrics were considered in the calculation, including 1) percent of cloud cover 2) 100 * (Dt – D0/183), where Dt and D0 are the image acquisition date and July 1 of the year on Julian day, and 3) sensor type: where sensors were ranked based on their age and sensor issues based on the time window. 100 for OLI images, 50 for ETM+ images before 2004 and 10 for ETM images after 2004 (due to the SLC-off issues), and 30 for TM images.

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[69] Terrapulse, 2022. Appendix IV: Quality Assessment for TCC and forest datasets. In Technical Document: Estimation of Activity Data on Deforestation, Forest Degradation and Enhancement of Forest Carbon Stocks of Dominican Republic using Annual Time Series Analysis of Landsat data. 19p. https://app.box.com/s/hubmaeleboslxwuldev3gv5941dzcrbg

	• The four images with the highest scores were selected as the final image set for a year. Up to 148 images could be selected for a WRS-2 tile for the entire Landsat record to ensure complete temporal coverage. **Image composite**: After the scene selection step is completed, data is processed to TCC. Once TCC per Landsat tile is generated, a per-pixel compositing rule is applied to mosaic Landsat images with overlapping area for the country. This results in the most inclusive sample set, increasing the likeliness of filtering out anomalous estimates, such as contamination by residual clouds, SLC-OFF issues etc. The TCC estimates belonging to a year were then aggregated to produce the final annual estimate at each pixel for a given year, where the median operator was used to select the final pixel estimate from the selected TCC estimate group, and per pixel RMSE was calculated from the group to measure the uncertainty of the TCC estimate for the year. **Visual Assessment**: After the completion of TCC mosaicking, the next step entails processing of time serial forest cover and change estimates using the globally calibrated TCC estimates. The globally calibrated TCC and forest activity assessment were then put on terraView (https://www.terrapulse.com/terraView/dr/) for the local partners at DR to visually assess the data for glaring and large-scale issues. No issues were reported and TCC did not need to be calibrated based on the validation exercise. The final TCC and post processed forest change datasets were visualized in an interactive map interface for assessment and were also validated using DR provided land cover maps. The high-resolution satellite images were also loaded into the interface as a reference during the examination. Although the high- resolution satellite map may not provide the exact representation of the forest at a given point in time of the evaluated TCC or forest changes, it could still provide the knowledge that is valuable for understanding the general pattern and distribution of forests in the region. Scene boundaries and large errors in the TCC process or forest change detection processes could be picked up by the visual examination by evaluating the spatial and temporal consistency as well as the consistency with the reference map. Additionally, internally the team at terraPulse used a time-series NDVI profile for selected regions to understand the phenological dynamics of the forests and forest activity.
Uncertainty associated with this parameter:	The canopy cover change category determination uncertainty for each sampling plot in the systematic grid was calculated at **6%** for degradation and canopy cover recovery classes[70]. This uncertainty was calculated by the bootstrap method, with 1000 simulations based on the bias estimate. The bias of the canopy cover in Forest Cover maps is 4.34%, with a standard deviation of 61.691. Tree canopy cover reference data collected by the Dominican Republic team was overlaid with coincident terraPulse tree canopy cover estimates. The reference data from the terraPulse estimates were subtracted to calculate the bias of each terraPulse data point. The scipy open-source python package (https://scipy.org) was used to fit a Normal distribution of the terraPulse bias using Maximum Likelihood to estimate the mean and variance parameters.

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[70] The Excel tool used to estimate the canopy cover change category determination uncertainty by the bootstrap method can be accessed at the following link: https://app.box.com/s/ex2otzvkk4u32armla8rory8as9iu7tj

The sampling error of estimating the areas of the canopy cover class change was also calculated (table below). Both uncertainties are included in the propagation error of the reference emission level.

Table 3-24: Sampling error of canopy cover transition areas in permanent forest lands -2019-2021

Canopy cover transition in permanent forest lands		Area 2006-2015 (ha)
Wet Broadleaf Forest	Enhancement	21%
	Degradation	21%
Dry Broadleaf Forest	Enhancement	28%
	Degradation	51%
Pine Forest	Enhancement	38%
	Degradation	51%
Agricultural Tree Crops	Native forest	NA
Native forest	Agricultural Tree Crops	NA
Mangroves	Enhancement	139%
	Degradation	NA

Any comment:	There are no comments.

4 QUANTIFICATION OF EMISSION REDUCTIONS

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

The following table shows the Reference Level for the ER Program for the Reporting Period covered in this report. This Reference level was technically corrected according to the Technical and Methodological proposal submitted by the Dominican Republic responding to the conditions pointed out in resolution CFM/20/2019/5. A pro-rata's factor was applied to adjust the Emission Reductions presented in this Monitoring Reporting. The Reporting Period starts on March 1st and ends on December 31st, 2021; therefore, the pro-rata's factor is 0.84.

Monitoring period	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e})	Average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e})	Annual historical removals by sinks over the Reference Period (tCO_{2-e})	Adjustment, if applicable (tCO_{2-e})	Reference level (tCO_{2-e})
2,021	2,559,729	624,244	-3,278,409	NA	-94,437
Total	2,559,729	624,244	-3,278,409	-	-94,437

Technical Corrections applied to the Reference Level.

The provisional inclusion of the Dominican Republic's Emission Reductions Program Document (ER-PD) into the portfolio of both Tranche A and Tranche B of the Carbon Fund was deemed approved upon fulfillment of the submission of a document to the Facility Management Team (FMT) detailing any proposed additional technical corrections to be made to the Reference Level before the first verification. In September 2019, the Dominican Republic presented a technical and methodological proposal responding to the conditions pointed out in resolution CFM/20/2019/5[71]. The Technical Corrections Proposal addressed the following improvements:

1. Biennial data on deforestation of primary and secondary forest, degradation, restoration, deforestation, all data on a pixel basis wall-to-wall.
2. Monitoring and emission factors of soil organic carbon using a considerably improved methodological approach, especially given the significance of soil carbon in mangroves; and
3. Estimation of separate emission factors for the secondary and primary forest.

In response to the comments of the Chair summary report, a stepwise approach was used to update the reference level for the period 2006-2015. The technical corrections applied to the original Reference Level have been made following this technical and methodological proposal. All the technical modifications are in line with paragraph 2 of the "Guideline on the application of the methodological framework Number 2: Technical corrections to GHG emissions and removals reported in the reference period". Technical corrections do not compromise the consistency of GHG emissions and removals estimates between the Reference Period and monitoring periods, as both calculations apply the improvements. None of the improvements relate to a change in policy and design decisions affecting the Reference Level. Carbon pools and gases, GHG sources, reference period, forest definition, REDD+ activities, Accounting Areas, forest types remain unchanged.

Activity data on deforestation of primary and secondary forests and restoration: Corrections to historical activity data result from the use of reference data of higher spatial and temporal resolution than the one used at the time

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[71] The Technical and Methodological Proposal Responding to the Conditions Pointed out in Resolution CFM/20/2019/5 can be accessed at the following link: https://www.forestcarbonpartnership.org/system/files/documents/DR_Technical%20note%20Responding%20to%20the%20Conditions%20Pointed%20out%20in%20Resolution%20CFM2020195.pdf

of submission of the final ER-PD. The methods used to estimate activity data are aligned with IPCC and GFOI guidance and guidelines.

Before deciding on using sampling-based estimates, deforestation and regeneration activity data based on pixel-based wall-to-wall was assessed. It was evaluated the option of using activity data calculated from the geographic comparison of biennial Forest Cover (FC) maps produced by TerraPulse for the Dominican Republic. TerraPulse developed biennial satellite-derived (FC) maps applying data extraction and automatic learning algorithms to large volumes of satellite images to monitor deforestation, reforestation, degradation, and forest recovery.

Based on biennial FC maps, a land-use change map was prepared for the Reference Period 2005 to 2015. This map was validated following Olofsson's (2014) guidelines[72]. A systematic grid of 7,697 sampling points (2.5*2.5 km) was used to obtain reference data for the validation process. The land-use change map includes the following categories: Lakes and other water bodies (CUERPOSAGUA), Forest land remaining as forest since 2001 (B2001), Non-Forest converted to forest lands (BSEC), Forest land converted to non-forest lands (DEFOB2001), Secondary Forest converted to non-forest lands (DEFOBSEC), and Non-Forest lands remaining as non-forest lands (NOBOSQUE).

All estimates of Land-use transitions and stable classes based on TerraPulse data fell outside the confidence intervals of the sampling-based estimates. According to the land-use change validation (see Table 4.1), deforestation and regeneration activity data based on pixel-based wall-to-wall maps present significant bias. The bias is above 47% for all land-use transitions except for permanent forests (B2001). Therefore, option 3 of the Technical and Methodological Proposal responding to the conditions in Resolution CFM/20/2019/5 was used to estimate stable land-use classes and land-use transitions.

Only sampling-based estimates and associated uncertainties were used to calculate the activity data. Annual activity data for deforestation and forest regeneration were derived from the sampling procedure (7,697 sampling grid), where years of transitions were recorded for each point.

Table A4.1: Validation of the land-use change map 2006-2015.

Category of land-use change for the period 2006-2015	code	Number of samples	Producers' accuracy	Users' accuracy	Map pixel count area (ha)	Sampling random estimate (ha)	90% Confidence interval (ha)	Map area fall inside CI	Bias
Lakes and other bodies of water	CUERPOSAGUA	113	0.88	0.85	72,130	70,834	10,881	Yes	1.80%
Forest land remaining as forest since 2001	B2001	2759	0.68	0.73	1,639,993	1,729,469	43,378	No	-5.46%
Non-Forest converted to forest lands	BSEC	406	0.36	0.14	642,975	254,500	20,222	No	60.42%
Forest land converted to non-forest	DEFOB2001	160	0.26	0.06	460,947	100,295	12,907	No	78.24%
Secondary Forest converted to non-forest lands	DEFOBSEC	3	0.67	0.01	204,890	1,881	1,786	No	99.08%
Non-Forest lands remaining as non-forest lands	NOBOSQUE	4253	0.59	0.86	1,802,019	2,665,977	44,972	No	-47.94%

Forest degradation activity data: Activity data used to calculate emissions and removals due to degradation and canopy recovery in forest remaining forests were also determined with sampling-based estimates (7,697 systematic grid). Canopy cover category maps for 2005 and 2015 were prepared, including three classes: 30-60%, 60-85%, and >85%. Canopy cover change map 2006-2015 was prepared from terraPulse FC maps considering only pixels with canopy cover probability of 90% or above. Both maps were geographically compared to obtain the canopy cover change map 2005-2015, including the following classes: i. Lakes and other bodies of water, ii. Stable Forest, iii. Forest with degraded canopy cover, iv. Forest with canopy cover recovery and v. non-Forest lands and Secondary Forest.

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[72] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

Table A4.2 compares the pixel count area of the canopy cover change map with the random sampling estimate based on 2,083 sampling points reference data. Reference data were based on the interpretation of high-resolution imagery. The canopy cover change map overestimates canopy cover transitions (more than 52% bias). However, the Stable Forest bias is 14%.

Considering that data based on pixel-based wall-to-wall could overestimate activity data, sampling-based estimates were used to determine degradation and canopy recovery (using 7,697 systematic grid). Also, considering that FC maps provide a more robust determination of Canopy Cover than high-resolution imagery interpretation, forest cover and its probability were extracted from FC maps for each sampling point located in a permanent forest in the systematic grid. This information made it possible to assign each point the canopy cover class 30-60%, 60-85%, and >85% for the later analysis of canopy cover change.

Table A4.2. Validation of the canopy cover change map 2006-2015.

Category of canopy cover change for the period 2006-2015	code	Number of samples	Producers' accuracy	Users' accuracy	Map pixel count area (ha)	Sampling random estimate (ha)	90% Confidence interval (ha)	Map area fall inside CI	Bias
Lakes and other bodies of water	CUERPOSAGUA	9	0.78	0.78	71,824.50	21,238.81	11,620.27	No	70%
Stable forest	ESTABLE	355	0.42	0.46	733,270.41	837,753.05	66,484.40	No	-14%
Forest with degraded canopy cover	DEGRADADO	40	0.15	0.06	249,131.97	94,394.71	24,310.27	No	62%
Forest with canopy cover recovery	RECUPERACION	97	0.24	0.12	477,467.91	228,907.17	37,314.42	No	52%
Non-forest lands and Secondary Forest	NOBOSQUEYRE GENERACION	1542	0.82	0.91	3,289,515.03	3,638,916.08	75,488.44	No	-11%

Revised methodological approach for estimating the annual stock change of Soil Organic Carbon (SOC): The annual change in the SOC pool estimate was technically corrected. The updated SOC pool change calculation is now based on Equation 2.25 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. SOC emissions associated with deforestation now include the land-use changes occurring in the Reference Period and the emissions resulting from land-use changes in previous years ("legacy emissions"). Full implementation of this approach was possible since a long time series of deforestation activity data was available based on 1984-2021 annual FC maps that let going back at least 20 years before the start of the Reference Period to estimate legacy emissions correctly.

It was assumed that the Soil Organic Carbon stock change during the transition to a new equilibrium SOC occurs linearly over 20 years. The Land Units represent yearly classes from the land-use change analysis used in setting the reference level. Also, Land Units maintain the same forest types as those used in the land-use change analysis provided in the ER-PD.

Additionally, new SOC values (before and after forest transition) were collected to replace the original estimates sourced from National Forest Inventory. The soil organic carbon pool estimates in the NFI of the Dominican Republic presented errors and methodological limitations. NFI soil samples were collected from the upper 15 cm of soil. However, the soil organic carbon stock was calculated from the upper 30 cm. Generally, the SOC decreases with sampling depth. Also, the gravel content was ignored during the SOC pool calculation. Rock fragments do not have organic carbon, and the coarse stone percentage is sometimes very high. Calculate SOC at 30 cm using soil values taken at 15cm, and without considering the coarse volumetric ratio, overestimate the pool of SOC and, consequently, the deforestation emission factor.

To avoid the overestimation of SOC, two hundred sixty paired plots were established (130 in forest lands and 130 in non-forest use) to measure Soil Organic Carbon before and after deforestation, comparing the SOC between pairs by type of vegetation. Inventory plots were evenly distributed in landscape units according to soil type and land use. The soil was sampled at 15 cm and 30 cm depth in paired plots established for each landscape unit. Soil organic carbon stock (SOCS) was computed as the product of three variables, organic carbon content (SOC), bulk density (BD), and stoniness (S). Soil organic carbon stock (SOCS) was calculated with the following equation:

$$SOCS_i = SOC_i \times BD_i \times D(1 - S_i) \qquad \text{Equation A4.1}$$

Where SOC is the soil organic carbon concentration percentage (g 100g^{-1}), BD is bulk density (g cm^{-3}), D is the thickness of the layer (30 cm), and S is the proportion of the volumetric coarse fragments fraction (g g^{-1}).

Finally, SOC stocks were compared between paired plots (forest cover and non-forest land-use) to estimate the carbon stock change for each transition. The exchange rate of SOC was also calculated, considering the time elapsed from deforestation based on the land-use history of the plot determined by interviewing the landowner and, where possible, validated with time-series satellite imagery.

Estimation of separate emission factors for the secondary and permanent forest:

TerraPulse developed annual forest cover maps based on the canopy cover and probability of change in forest cover from one year to another. This information offers long-term and consistent mapping and monitoring of forest cover. It allows the retrieval of historical reference scenarios from the satellite records and the detection of deforestation, degradation, and growth over time. Based on FC maps, a forest cover change analysis was prepared considering only pixels with> 90% probability of having a forest cover higher than 30%, 60% and 85%. Subsequently, forest degradation classes and secondary forest cohorts were mapped into four categories: i. Intact Forest (>85% crown cover), ii. Degraded Forest (60-85% crown cover), iii. Highly degraded forest (30-60% crown cover) and Secondary Forest.

All forest inventory plots in forest and tree-shaded crops were classified into four categories based on terraPulse data. By forest type and degradation class, carbon content was directly derived from the biomass sampling plots database (average and 90%CI; see table below). The mean annual increment of secondary forest and tree-shaded crops (tC/ha/yr.) was estimated by dividing standing biomass by the age determined from the forest cover change maps. In secondary forest types additional forest plots were inventoried. A series of 32 secondary sampling units were inventoried in 2021, and age was determined from different sources: interviews and satellite information and secondary data. The standing biomass of these plots was divided by age to estimate mean annual increment rates (tC/ha/yr.).

Table 4-1. **Total forest biomass and non-forest land uses.**

Land uses			Total Biomass (AGB+BGB+L+DW)	
			tC*ha^{-1}	**n**
Permanent Forest	Pine	Intact forest	76.52 ± 7.4	25
		Degraded forest	47.79 ± 10.3	14
		Very degraded forest	44.19 ± 17.46	6
	Dry Broadleaf Forest	Intact forest	43.43 ± 7.85	6
		Degraded forest	42.63 ± 7.59	10
		Very degraded forest	35.35 ± 14.24	21
	Wet Broadleaf Forest	Intact forest	80.72 ± 11.75	75
		Degraded forest	50.91 ± 8.89	67
		Very degraded forest	39.38 ± 11.02	40
	Agricultural tree crops		64.93 ± 10.32	58
Secondary Forest	Pine	4-22yr	37.97 ± 23.15	9
		22-44yr	57.49 ± 14.33	14
	Dry Broadleaf Forest	4-22yr	27.62 ± 7	19
		22-44yr	30.2 ± 4.81	33
	Wet Broadleaf Forest	4-22yr	25.04 ± 4.24	39
		22-44yr	47.59 ± 8.69	59
				495

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

The Emission Reduction Calculation is made with the Equation 1. The quantification of emissions and removals during the Reporting Period was done following the measurement and monitoring procedures described in section 2.2.1-Figure 2-2, the equations described in section 2.2.2 of this Monitoring Report and applying the approaches to determine activity data and emission, or removal factors included in the data and parameter tables on section 3 above. Table 2.2 describes the set of tools developed by the Dominican Republic to estimate emissions and removal from deforestation, degradation, and forest regeneration. The set of tools for emission and removal estimation can be accessed at the following link:

https://app.box.com/s/zqfnzgwtur4qtsde2in1ucrlwbg7krxn

Emission reduction calculation ($\mathbf{ER_{ERP,t}}$)

$$\mathrm{ER_{ERP,t}} = (\mathrm{RL_t} - \mathrm{GHG_t}) \times \frac{44}{12}$$ **Equation 10**

Where:

$\mathrm{ER_{ERP,t}}$ = Emission Reductions under the ER Program in year t; $tCO_2e*year^{-1}$.

$\mathrm{RL_t}$ = Net emissions of the RL from over the Reference Period; $tCO_2e*year^{-1}$. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.

$\mathrm{GHG_t}$ = Monitored net emissions at year t; $tCO_2e*year^{-1}$;

$\frac{44}{12}$ = Conversion of C to CO2

Emissions by sources and removals by sinks from the ER Program during the Monitoring Period.

Year of Monitoring Period	Emissions from deforestation (tCO_{2-e}/yr)	If applicable, emissions from forest degradation (tCO_{2-e}/yr)*	If applicable, removals by sinks (tCO_{2-e}/yr)	Net emissions and removals (tCO_{2-e}/yr)
2,021	1,932,457	5,559,875	-9,836,942	-2,344,610
Total	1,932,457	5,559,875	-9,836,942	-2,344,610

4.3 Calculation of emission reductions

The Reporting Period does not coincide with the Monitoring Period. Monitoring period starts January 1st and ends December 31st, 2021. The Monitoring Period starts March 1st and ends December 31st, 2021. A pro-rata allocation was needed by multiplying the net ERs during the Monitoring Period by the ratio of the Length of the Reporting Period and the Length of the Monitoring Period.

Total Reference Level emissions during the Monitoring Period (tCO_2-e)	**-94,437**
Net emissions and removals under the ER Program during the Monitoring Period (tCO_2-e)	**-2,344,610**
Emission Reductions during the Monitoring Period (tCO_2-e)	**2,250,173**
Length of the Reporting period / Length of the Monitoring Period (# days/# days)	**305**

Emission Reductions during the Reporting Period (tCO_2-e)	**1,880,282**

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

A Pro-rata factor was applied to estimate the volume of ERs for the Reporting Period. The pro-rata factor corresponds to the fraction of the year 2021 between March 1st and December 31st. The uncertainty of the estimate of emission reductions for the Reporting Period and Monitoring Period are very similar (221% for Reporting Period and 217% Monitoring Period).

5.1 Identification, assessment and addressing sources of uncertainty

In the following table the country identifies and discuss in qualitative terms the main sources of uncertainty and its contribution to total uncertainty of Emission Reductions. The measures that have been implemented to address these sources of uncertainty as part of the Monitoring Cycle are also discussed.

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
Activity Data						
Measurement	✓	✓	**Land-use photo-interpretation**: Land-use visual assessment uncertainty is associated with the photo-interpretation consistency and the quality of the imagery dataset used for the assessment. Bias in the photo-interpretation of land use was mitigated by employing criteria standardization and decision trees for visual evaluation of high- and low-resolution images. Before each monitoring event, training exercises were carried out using common samples until satisfactory consistency is achieved to reduce variability between photo interpreters. During the land-use visual interpretation process, a specialist with extensive experience supervised the work of the analysts. The supervisor reviewed monthly deliveries of photo-interpreted points. This review focused on identifying and correcting errors and checking transition consistency and the years of change registered. According to QA/QC procedures, the minimum level of consistency between the analysts and the supervisor should be 90% on land-use interpretation Regarding imagery quality, Planet images on Collect Earth Online (http://collect.earth/) provided 100% availability of high-res cloud-free images for all sampling points on the systematic grid.	High	Yes	No
Measurement	✓	✓	**Canopy cover determination**: Canopy Cover was extracted from Tree Canopy Cover maps developed by terraPulse for each sampling point located in the permanent forest class in the systematic grid. TCC maps were used to mitigate the potential errors in canopy cover determination due to analyst interpretation bias or lack of hi-res imagery in the sampling plot. The uncertainty determination of the total sampling point assigned to each canopy cover change class was made with the bootstrap method, with 1000 simulations based on the bias estimate[73]. The bias of the canopy cover in Forest Cover maps is 4.34%, with a standard deviation of 61.691. Tree canopy cover reference data collected by the Dominican Republic team was overlaid with coincident terraPulse tree	Low	Yes	Yes

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[73] The Excel tool used to estimate the canopy cover change category determination uncertainty by the bootstrap method can be accessed at the following link: https://app.box.com/s/ex2otzvkk4u32armla8rory8as9iu7tj

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
			canopy cover estimates. The reference data from the terraPulse estimates were subtracted to calculate the bias of each terraPulse data point to estimate the bias. The scipy open-source python package (https://scipy.org) was used to fit a normal distribution of the terraPulse bias using Maximum Likelihood to estimate the mean and variance parameters.			
Representativeness	✓	✓	Sampling-based estimates and associated uncertainties were used to calculate the activity data. Annual activity data for deforestation, degradation, and forest regeneration were derived from the systematic sampling procedure (7,697 Permanent Sampling Units) to ensure the representativeness of the activity data estimate.	Low	Yes	No
Sampling		✓	The density of the systematic grid was estimated from the analysis of 474 systematic sampling points collected by Ovalles (2018)[74]. According to this analysis, with a sample size of 1942, it is possible to achieve a standard error of global precision of S(ô) = 0.01. However, DIARENA established a 2.5 x 2.5 km grid with 7,697 sampling points to reduce the standard error in uncommon transitions.	High	Yes	Yes
Extrapolation	✓		Annual activity data for deforestation, degradation, and forest regeneration were derived from the systematic sampling procedure (7,697 Permanent Sampling Units). Activity Data were estimated with no stratification. No extrapolation of the AD estimate was necessary.	NA	NA	NA
Approach 3	✓		***Permanent Sample Units*** (PSU) of one hectare (100 x 100 meters) with a single evaluation point corresponding to the plot centroid was used for the land-use visual assessment. PSUs ensured the ***temporal tracking of land use***. Land-use assessments were made for 2000, 2005, 2015, 2018 and 201. The land-use class was interpreted with context and recorded for the individual pixel or point for t1 and t2. Using the land-use type at t1 and t2, the change class was determined for the pixel or point. Using single point Land-use change class information, areas of change were calculated for the population. Interpreters also collected the ***transition year*** in the PSUs with a land-use change registered between assessments.	Low	Yes	No
Emission Factor						
DBH measurement	✓	✓	Three sources of data were used to estimate total biomass in each of the land uses and the emission factors in the land-use change categories: a. The National Forest Inventory (**NFI**)[75], b Assessment of Biomass and Carbon Content in Non-Forest Cover in the Dominican Republic" (**ISNB**)[76], and c. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015 (**Technical Correction Inventory**) [77]. The three inventories were compiled using the same methodology, sampling unit, and nested plots in order to determine carbon density for	Low	Yes	No
H measurement	✓	✓		High	Yes	No
Plot delineation	✓	✓		Low	Yes	No

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[74] Ovalles, P. (2018). Elaboración de mapa de Uso y Cobertura del Suelo 2015. Análisis de Cambios y Mapa de Deforestación en la República Dominicana. Informe Final. Santo Domingo, República Dominicana.

[75] Ministry of the Environment. 2015. Inventario nacional forestal de la República Dominicana: Measure and assess forests in order to understand their diversity, composition, volume and biomass. Field Manual. Forest Monitoring Unit. REDD7CCAD-GIZ. Regional Project 48 pages

[76] Ministry of the Environment. 2017. Assessment of the biomass and carbon content in non-forest systems in the Dominican Republic. Field Manual. Forestry Monitoring Unit REDD+ Preparation Project. 54 pages

[77]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
			each component recognized as a sink. Each carbon pool is estimated using the database at the tree level, taking the area of the sampling units into account. **NFI**: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[78] and QA/QC[79] procedures to reduce non-sampling errors. Since the beginning of the planning phase, courses on basic forest inventory techniques were given to 68 forestry technicians, half of them MARN officials and the other half personnel who work outside the Ministry. Then, three-day training workshops were held on INF-RD Field Manual, with the participation of 97 technicians selected. Subsequently, the crews responsible for the field survey were designated and received rigorous training in the Field Manual and the Quality Control Manual. **ISNB**: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[80] to reduce non-sampling errors. The crew members for the fieldwork received training for implementing inventory methodology and QA/QC procedures. The inventory methodology was explained, and field practices were carried out, including measurements and sampling exercises. During this training, the crew leaders were confirmed according to their abilities and capacities. **Technical Correction Inventory:** The quality control procedures during the implementation of the survey of the 32 additional plots have been made following the NFI´s Field Manual and QA/QC procedures prepared by the Ministry of Environment and Natural Resources. The Forest Monitoring Unit of the Ministry has formed a quality control brigade that applied the QA/QC procedures in these additional plots; Likewise, the MARN QA/QC team and fieldwork crews were trained. Both teams worked together for two days, putting the inventory QA/QC protocol into practice.			
Wood density estimation	✓	✓	Wood density was obtained from the literature, mainly from Chave et al. (2006)[81]. Gender or family values were used for not-found species (genus/species). For species unknown or not found at any taxonomic level, all found species average density was used.	High	No	No
Biomass allometric model	✓	✓	There are no specific allometric equations for broadleaf forests in the Dominican Republic. Above-ground biomass (AGB) calculations are carried out using the allometric equations of Chave et al. (2014)[82] in the three inventories. For pine trees, a local allometric equation is used. Allometric equations developed in Nicaragua and Costa Rica are used for coffee, cocoa, coconut, mango, avocado, and guava. None of the non-local allometric equations are validated. The uncertainty of allometric equations was not propagated in the MC analysis. It is pending the propagation of this error in the MC simulation, increasing the sampling uncertainty of AGB and BGB by 10% at a 90% confidence level using the quadrature approach.	High	No	No

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[78] MARN-GIZ. 2014. Manual de Campo del Inventario Nacional Forestal de la República Dominicana. Unidad de Monitoreo Forestal. Programa REDD CCAD GIZ. Santo Domingo, R.D. 61p. https://app.box.com/s/e0jf1lb49wpbd2981f9iwvvo2gvbf0av

[79] MARN-GIZ. 2018. Protocolo para el control de calidad del Inventario Nacional Forestal de Republica Dominicana 2018. Unidad de Monitoreo Forestal y Unidad de Gestión del Proyecto de Preparación REDD+ de la República Dominicana. 9p. https://app.box.com/s/b9uoly8bpn5n4b8xivhtv2ob3z2gslub

[80] MARN, 2017. Manual de Campo: Evaluación del contenido de biomasa y carbono en sistemas de No Bosque en la Republica Dominicana. Unidad de Monitoreo Forestal. Proyecto de Preparación de REDD+. 54p. https://app.box.com/s/056lacpm9rwyw2uh7a0aqz4a5yye9ol4

[81] **Chave, J. 2006.** Medición de densidad de madera en árboles tropicales. Proyectos Pan Amazonía - RAINFOR. 7 pp.

[82] Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, *20*(10), 3177–3190. https://doi.org/10.1111/gcb.12629

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
Sampling		✓	Sampling plots were randomly located. A total of 573 plots were collected, with estimations of the above-ground biomass (AGB), dead material (DM), and litter (L). This sample size allowed robust estimates of carbon densities for the different forest types (permanent and secondary) and non-forest land uses.	Low	Yes	Yes
Other parameters (e.g. Carbon Fraction, root- to-shoot ratios)			The Cairns et al. (1997) [83] equation is used to quantify below-ground biomass roots. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47).	High	Yes	No
Representativeness	✓		Based on Canopy Cover maps, a forest cover change analysis was prepared considering only pixels with> 90% probability of having a forest cover higher than 30%, 60%, and 85%. Subsequently, forest degradation classes and secondary forest cohorts were mapped into four categories: i. Intact Forest (>85% crown cover), ii. Degraded forest (60-85% crown cover), iii. Highly degraded forest (30-60% crown cover) and iv. Secondary Forest. All forest inventory plots in forest and tree-shaded crops were classified into these four categories based on terraPulse data. By forest type and degradation class, carbon content was directly derived from the biomass sampling plots database (average and 90%CI) to ensure the representativeness of carbon density estimates. Also, the mean annual carbon change in secondary forest and tree-shaded crops (tC/ha/yr.) was estimated by dividing the carbon change between non-forest and secondary forest land use by the time elapsed to reach the maximum biomass of the secondary forest type determined from the forest cover change maps.	Low	Yes	No
Integration						
Model	✓		Control Mechanisms of material errors have been included in emission and removal calculations tools; i.e., sums of sampling points by forest type coincide with sample size ensuring no double counting in the sample-based activity data estimate.	Low	Yes	No
Integration	✓		Activity Data and Emission Factors are fully comparable. Carbon densities have been estimated according to the forest types (permanent and secondary), and non-forest land uses interpreted in the visual assessment of hi-res imagery and Forest Cover maps.	Low	Yes	No

5.2 Uncertainty of the estimate of Emission Reductions

Parameters and assumptions used in the Monte Carlo method

Dominican Republic ER Program applied Monte Carlo methods (IPCC Approach 2) for quantifying the Uncertainty of the Emission Reductions. Because the MC propagation analysis includes more than 700 parameter values, it has been provided access to uncertainty and emission factor calculation tools to see all parameter values used in the analysis. The sources of uncertainty propagated in the Monte Carlo (MC) analysis are provided in the following Table.

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[83] Cairns, M. A., Brown, S., Helmer, E. H., Baumgardner, G. A., Cairns, M. A., Brown, S., … Baumgardner, G. A. (1997). Root Biomass Allocation in the World ’s Upland Forests. Oecologia, 111(1), 1–11. http://doi.org/10.1007/s004420050201

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Permanent Forest's Degradation and carbon Enhancement Activity Data	**Twenty-one** values for the Reference Period and **16** activity data for the Monitoring Period were included in MC analysis. See all values in the Uncertainty calculation tool[84], "Deforestacion y Degradacion" Sheet – (Reference Period cells A11..A58, Monitoring Period cells B11..B58)	The error of Tree Canopy Cover change classes (estimated with the bootstrapping method)[85] and Sampling Error of activity data estimate was included in Monte Carlo error propagation.	Normal	Truncated Normal distribution (values > 0) was assumed for sample-based activity data estimate and the bias of Tree Canopy Cover maps.
Deforestation Activity Data	**Thirty** values for the Reference Period and **6** activity data for the Monitoring Period were included in MC analysis. See all values in the Uncertainty calculation tool "Deforestacion y Degradacion" Sheet – (Reference Period cells T59..T122, Monitoring Period cells AG59..B122)	Standard error of activity data estimate	Normal	Truncated Normal distribution (values > 0) was assumed for sample-based activity data estimate
Activity Data for estimating SOC emissions associated with deforestation	The MC analysis included **167** Deforestation SOC Activity Data values and **4** values of Permanent Forest areas estimate. See all values in the Uncertainty calculation tool "EmisionesHeredadasSOC" Sheet – (Wet BL forest cells C23..C64; Dry BL forest cells C169..C210; Pine forest cells C315..C356; Tree-shaded crops cells C461..C502)	Standard error of activity data estimate	Normal	Truncated Normal distribution (values > 0) was assumed for sample-based activity data estimate
Activity Data for estimating inherited removals	The MC analysis included **442** Activity Data values for estimating inherited removals. See all values in the Uncertainty calculation tool "RemocionesHeredadas" Sheet – (Wet BL forest cells E25..Q62; Dry BL forest cells E78..Q115; Pine forest cells E131..Q167; Tree-shaded crops cells E184..Q220; Mangroves E237..Q274)	Standard error of activity data estimate	Normal	Truncated Normal distribution (values > 0) was assumed for sample-based activity data estimate

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[84] Uncertainty calculation tool can be accessed at the following link: https://app.box.com/s/l2pwff1juz77xo4b4r4g48q2lj6ukdh9

[85] Error of Tree Canopy Cover change classes estimation tool can be accessed at the following link: https://app.box.com/s/ex2otzvkk4u32armla8rory8as9iu7tj

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Deforestation and Degradation Emission Factors	The MC analysis included **21** Carbon density values for forest types (secondary and permanent) and non-forest land uses categories considered in emission estimate. See all values in the Uncertainty calculation tool "FactoresEmision" Sheet – (cells G6..G26)	90% Confidence Interval of Carbon density estimate.	Normal	Truncated Normal distribution (values > 0) was assumed for all carbon density estimates.
Soil Organic Carbon Linear decreasing rate	The MC analysis included **4** SOC Linear decreasing rate values. See all values in the SOC Emission Factor calculation tool[86] "SOCEF" Sheet cells J7..J10.	Estimate error calculated combining uncertainty of SOC content before and after land-use transition with IPCC's Approach 1 equation 3.2.	Normal	Truncated Normal distribution (values > 0) was assumed for SOC linear decreasing rate estimates.
Removal factors	The MC analysis included **8** Removal factors. See all values in the Carbon Densities calculation tool [87]"CarbonDensities" Sheet cells G45..G62.	Estimate error calculated combining uncertainties of non-forest land use and secondary forest carbon density with IPCC's Approach 1 equation 3.2.	Normal	Truncated Normal distribution (values > 0) was assumed for Removal factors estimates.

Quantification of the uncertainty of the estimate of Emission Reductions

		Reporting Period		Crediting Period	
		Total Emission Reductions*	**Forest degradation****	**Total Emission Reductions***	**Forest degradation****
A	**Median**	2,238,180	NA	1,827,189	NA
B	**Upper bound 90% CI** (Percentile 0.95)	6,309,605	NA	5,189,966	NA
C	**Lower bound 90% CI** (Percentile 0.05)	-1,526,932	NA	-1,259,428	NA
D	**Half Width Confidence Interval at 90% (B – C / 2)**	3,918,268	NA	3,324,697	NA
E	**Relative margin (D / A)**	175%	-	176%	-
F	**Uncertainty discount**	15%	-	15%	-

*Forest degradation is included in the ER estimate. ** Forest degradation has not been estimated using proxy data.

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[86] The SOC Emission Factor calculation tool can be accessed at the following link: https://app.box.com/s/7gynk2iz594xtwgkptgabhco4jvo9vo8

[87] The Carbon densities calculation tool can be accessed at the following link: https://app.box.com/s/x4dhc9qynotu4rwmn82mulysneirvrhv

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

The uncertainty of the estimation of each REDD activity included in the forest carbon accounting and monitoring period of the RE Program was calculated (Tables 5-1 and 5-2). The sensitivity analysis has been made at the REDD activity level due to the large number of parameters involved in the estimation of emission reductions and technical limitations for processing them with an MC analysis in Excel. The following tables show activities' contribution to the Emissions Reduction's uncertainty from net emissions. Likewise, the contribution of each activity is calculated separately for the ER from Emissions and ER from Removals (Table 5-3).

All REDD Activities estimates of emissions and removals present high uncertainties. This situation could be associated with the number of forest types included in the calculation. AD of uncommon transitions gives a very high estimation error. Permanent forest (TF-TF) carbon flow estimate showed the higher values for reference and monitoring period (TF-TF from 48% to 61%). Emission from deforestation and reforestation carbon removals present the lower values (15%-38%).

Emission from deforestation and reforestation carbon removals present the highest contributions to the global uncertainty. Sensitivity analysis results for ER from net emission are not consistent with uncertainties observed in emission and removals estimates. For this reason, a separate analysis of sensitivity was performed for RE from emission and RE from removals. The most significant contributor to the uncertainty of the ER of emissions is Forest Degradation (77% - ER TF-TF_E), and ER from reforestation is for RE from removals (46% RE OT-TF).

Table 5-1: Uncertainty of the estimation of each REDD activity included in the ER-Program forest carbon accounting for the Reference Period

t CO_2*año^{-1}	Emissions from deforestation (TF-OT_PR)	Emissions from degradation on permanent forest land (TF-TF_E_PR)	Removals for canopy recovery on permanent forest land (TF-TF_R_PR)	SOC emission from deforestation (TF-OT SOC_PR)	Reforestation removals (OT-TF_PR)	FREL / FRL
Median	1,229,965	791,327	-1,590,793	1,310,109	-1,871,896	-119,246
Upper bound 90% CI (Percentile 0.95)	1,616,813	1,342,427	-881,928	1,847,290	-1,564,673	811,181
Lower bound 90% CI (Percentile 0.05)	862,115	388,707	-2,419,527	796,847	-2,203,903	-1,109,573
Half Width Confidence Interval at 90%	377,349	476,860	768,800	525,222	319,615	960,377
Relative margin	**31%**	**60%**	**48%**	**40%**	**17%**	**805%**

Table 5-2: Uncertainty of the estimation of each REDD activity included in the ER-Program forest carbon accounting for the Monitoring Period

t CO_2*año^{-1}	Emissions from deforestation (TF-OT_2021)	Emissions from degradation on permanent forest land (TF-TF_E_2021)	Removals for canopy recovery on permanent forest land (TF-TF_R_2021)	SOC emission from deforestation (TF-OT SOC_2021)	Reforestation removals (OT-TF_2021)	Net Emissions (2021)
Median	1,666,143	6,362,042	-8,354,211	314,372	-2,321,467	-2,274,278
Upper bound 90% CI (Percentile 0.95)	2,350,729	10,716,306	-4,346,079	396,210	-1,967,281	1,241,907
Lower bound 90% CI (Percentile 0.05)	1,075,821	2,982,219	-13,903,928	237,007	-2,679,761	-6,313,076
Half Width Confidence Interval at 90%	637,454	3,867,043	4,778,924	79,602	356,240	3,777,492
Relative margin	**38%**	**61%**	**57%**	**25%**	**15%**	**166%**

Table 5-3: REDD Activities contribution to the Emission Reduction's global uncertainty of Monitoring Period

	REDD Activity	Parameters excluded from randomization	Median	Upper bound 90% CI (Percentile 0.95)	Lower bound 90% CI (Percentile 0.05)	Half Width Confidence Interval at 90%	Relative margin	Contribution
Net Emissions	**RE 2021**	No parameter was excluded	2,238,180	6,309,605	-1,526,932	3,918,268	175%	**0%**
	RE TF-OT	AD and EF	2,269,208	8,774,304	-3,869,644	6,321,974	279%	**59%**
	RE TF-TF_E	AD, EF, and Canopy cover	2,194,095	7,864,069	-2,043,615	4,953,842	226%	**29%**
	RE TF-TF_R	AD, EF, and Canopy cover	2,193,236	5,751,702	-2,345,778	4,048,740	185%	**5%**
	RE TF-OT SOC	AD, SOC linear decreasing rate	2,239,071	8,741,096	-3,890,007	6,315,551	282%	**61%**
	RE OT-TF	AD and Annual change in carbon stock in land converted to forest	2,230,361	8,768,155	-3,894,921	6,331,538	284%	**62%**
Emissions	**RE Emissions**	No parameter was excluded	-5,007,923	-1,488,883	-9,487,958	3,999,538	80%	**0%**
	RE TF-OT	AD and EF	-4,988,749	-1,523,113	-9,428,497	3,952,692	79%	**1%**
	RE TF-TF_E	AD, EF, and Canopy cover	-5,010,392	-4,121,756	-5,937,936	908,090	18%	**77%**
	RE TF-OT SOC	AD, SOC linear decreasing rate	-5,021,498	-1,554,546	-9,457,260	3,951,357	79%	**1%**
Removals	**RE Removals**	No parameter was excluded	7,180,437	12,796,822	3,036,591	4,880,115	68%	**0%**
	RE TF-TF_R	AD, EF, and Canopy cover	8,993,779	15,531,573	2,868,497	6,331,538	70%	**4%**
	RE OT-TF	AD and Annual change in carbon stock in land converted to forest	1,444,034	1,989,200	920,263	534,468	37%	**46%**

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

This section explains the legal considerations related to the ability of the Program Entity to transfer Emission Reduction Titles (ERs). Transfer of title of ERs will be demonstrated through the following institutional arrangements and legal instruments:

i. **Letter on the Capacity of the RD to Transfer Titles of REs** and to subscribe to ER-PA. This document establishes the legal considerations related to the ownership of the ERs and the institutional capacity and competence to transfer them to the FCPF. This letter was signed on May 29th, 2020 (see https://app.box.com/s/m4gy02m1ym9xcin7vo31hv3jfjjzn2py). The Bank accepted this letter, together with other evidence provided to demonstrate fulfilment of the Conditions of Effectiveness of Sale and Purchase (COEs).

ii. **Joint Declaration that reaffirms the competence of the National Institutions for the transfer of ERs**, dated November 5th, 2019, based on the national legal and regulatory framework that grants the institutional capacity to the Program Entity to sign the ERPA agreement (Treasury). It also confirms the authority of the Ministry of the Environment and Natural Resources as the entity in charge of transferring the ERs Titles to the FCPF and formalizing the assignment and transfer contracts of these titles with the beneficiaries through the Executing Entities and Programs participating in the REDD+ Program (see https://app.box.com/s/he1ire3kxfgju1lv0jy37gdm38pqmuid).

iii. **Assignment Acts / Ownership Transfer Agreements Templates to transfer ERs titles** from the beneficiaries and groups of beneficiaries to the corresponding Executing Entity (see https://app.box.com/s/kaajb96gh7igf6z9jois5xyyxzl313b3) and from the Executing Entity of the ER Program to the Ministry of Environment and Natural Resources. They, in turn, will make the transfer to the FCPF (See https://app.box.com/s/v8xj5dlyg3a0lhmais93h9a5588yiba4). No agreements have been signed yet; therefore, no ERs have been transferred under the program.

A "Road Map" has been prepared to determine the deadlines for the signing and formalization of the ER Ownership Transfer Agreements and the enrollment and registration of beneficiaries for the 2021 reporting period (see https://app.box.com/s/qgywjqzjlb6lwm773cqis26d79vopbn9).

6.2 Implementation and operation of Program and Projects Data Management System

In accordance with criteria 37 and 38 of the FCPF Methodological Framework, the ERP requires a series of arrangements to avoid double accounting, double selling, and multiple claims to an ER Title. Any ERs from REDD+ activities under the ER Program sold and transferred to the Carbon Fund will not be used again by any entity for sale, public relations, compliance, or any other purpose. For this purpose, the Dominican Republic has made a decision to implement and maintain its own comprehensive national REDD+ Program and Projects Data Management System, and has implemented a Data Management System -DMS- (a Registry System of REDD+ initiatives at national level).

The Registry System of REDD+ projects and programs (RSPP)[88] is now operational and is hosted on servers of the Ministry of Environment at the following link https://redd.ambiente.gob.do/. A User Manual[89] has been prepared, and training has been provided to final users of the system[90].

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[88] A description of the Registry System of REDD+ programs and projects can be found at the following link: https://app.box.com/s/cicqswk4h2t0x71l2dvbbwr9mmyfdxev

[89] The User Manual of the Registry System of REDD+ projects and programs can be accessed at the following link: https://app.box.com/s/1xdn00zv7vtqcnsjd77enp9hvpr9iwn2 .

[90] The documentation report on the training workshop can be accessed at the following link: https://app.box.com/s/ya9f6d1377mpcxp4ziedhtn6vudgqkx3

Each Executing Entity (EE) must be registered in the REDD+ Initiative Registry in which all beneficiaries participating in REDD+ activities that may generate emissions reductions through which the CF can provide results-based payments, as well as the areas covered by each and the REDD+ activities carried out in them, and any other information the REDD+ Initiative Registry requires. The REDD+ Initiative Registry will be managed by the REDD+ Coordination Office (OCR Spanish acronym) and it sufficiently robust to avoid double count or over reporting the number of hectares intervened. The detailed procedures to use the Initiative Registry will be incorporated to a user guide and the Operations Manual of Benefit Sharing Plan (MOP).

The different Executing Entities will develop the process of disseminating information to potential beneficiaries, in such a manner that stakeholders interested in participating in the REDD+ Program may carry out the process of complying with the legal and administrative requirements to be incorporated. The beneficiaries must be able to demonstrate ownership or possession rights of the lands in which they plan to implement REDD+ activities with the support of EE. Also, they must carry out the REDD+ activities coordinated by the EE programs that will integrate the REDD+ Program.

Lands on which the beneficiaries will develop REDD+ activities must count on mitigation potential in accordance with the type of activity that is planned. In situations in which beneficiaries participate in more than one REDD+ type activity in the same property during the reporting period, such REDD+ type activities must be carried out in different areas of the property. The beneficiary shall voluntarily select the REDD+ type activities and the specific area (with geographic coordinates) of property he/she wishes to register in the REDD+ Program and shall request registration through the corresponding EE. The beneficiary could register up to two REDD+ type activities in different areas within the property through the same or different EEs. The registry has been designed to automatically avoid duplication of areas within a property.

Once the applicant has completed the requirements, and has been deemed eligible, he signs an assignment agreement with the corresponding EE, where he makes the legal transfer of ownership of emissions reduced in their property and receive the corresponding benefits according to the Benefit Sharing Plan (BSP). The EEs will enroll the beneficiary in the Registry of REDD+ Initiative, in accordance with the provisions in the guidelines for participation in the REDD+ Program in Section 3.3.

6.3 Implementation and operation of ER transaction registry

For the ERs transaction registry in response to indicator 38.1, the Dominican Republic has taken the decision to use the Centralized Transaction Registry System being developed by the World Bank. This centralized system will track all the transactions under the FCPF ER Program. If the Dominican Republic decides to implement its own national emission reduction transaction system after finishing the ERPA, it must have clear links to the basic information of projects and programs included in the National DMS of REDD+ Programs and Projects; ensuring that ERs are not emitted, sold or claimed by more than one entity. The registration process of REDD + initiatives in the National DMS of REDD+ Programs and Projects that is currently under design, will avoid double counting of initiatives that could be developed in the future, the information will be taken into account when operating the Centralized Transaction System of the World Bank (in the event that there are matching REDD + initiatives in space / time with the FCPF CF ERP).

6.4 ERs transferred to other entities or other schemes

In the country there is a forest carbon mitigation initiative, which has an effect on the El Zorzal Private Reserve and local communities located in the northern mountain range. This initiative functions through the Plan Vivo Standard and was since 2014 in the Plan Vivo pipeline, although its registration is no longer available (http://www.planvivo.org/project-network/project-pipeline/). The initiative was established with The Dominican Environmental Consortium (CAD), who has signed a contract to sell carbon bonds with three chocolate companies: Dandelin Chocolate (California), ChocoSol (Toronto) and Blue Vandana (Vermont). These chocolate companies pay an extra 200 dollars per tonne of Zorzal Cocoa produced organically in a sanctuary intended for the conservation of biodiversity, especially the conservation of the habitat of the migratory bird species Catharus bicknelli. The payment from the chocolate companies supplies the El Zorzal Fund, which ensures payment to small producers for reforestation of degraded areas, with native or endemic species. The payment to producers is made on the basis of a fixed amount per reforested hectare and compliance with various previously established requirements. Over a period of 20 years, 200 hectares will be reforested.

It is essential to note that this initiative is now called Choco-Carbono and it is not currently registered with any standard for the issuance of carbon titles. This forest carbon mitigation initiative is within the accounting area, as the ERP accounting area is the national territory. However, in the event that a sale occurs of carbon bonds originating from the aforementioned initiative with a Carbon Standard, they will be excluded from the accounting of ERs to be submitted to the Cooperative Fund for Forest Carbon. For this, monitoring will be performed of the formal registration of the initiative in question and the measurement and verification reports. The initiative with Plan Vivo Standard is on a small scale in terms of emission reductions (a total of 200 hectares reforested between 2014 and 2020, to be registered as a reforestation carbon project). Other mitigation initiatives generated separately from the FCPF will be duly registered in accordance with the explanation in ERPD Chapter 18.2, and any ERs generated by these initiatives will also be excluded from the ERs to be transferred to the Cooperative Fund for Forest Carbon, thereby ensuring that double accounting does not occur with the ER program.

To date, no ERs have been transferred to other entities or other schemes.

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)

The FCPF emissions reduction program guidelines for establishing a buffer identify[91] several risk factors and foresee an assessment mechanism to determine the Investment Risk ratios for each one. These risk factors are enumerated and assessed in Section 7.3.

7.2 Quantification of Reversals during the Reporting Period

Intentionally left blank. No reversals occurred 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*		+
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]**			–

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[91] FCPF ER Program Buffer Guidelines (2015), 22 p. Available at: https://www.forestcarbonpartnership.org/sites/fcp/files/2015/December/FCPF%20ER%20Program%20Buffer%20Guidelines.pdf

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

Reversal risk set-aside values included in this section are the same submitted in the final Emission Reduction Program Document[92] and updated for the 2021 period.

Risk Factor	**Risk indicators**	**Default Reversal Risk Set-Aside Percentage**	**Discount**	**Resulting reversal risk set-aside percentage**
Default risk	*N/A*	**10%**	*N/A*	*10%*
Lack of broad and sustained stakeholder support	The ERP was formulated on the basis of a fact-gathering process, involving participation and consultation, and including all players – whether within or without the forest sector – who are somehow linked to the deterioration and the deforestation occurring in the Dominican Republic. An array of platforms, sectors and social groups were systematically called upon. The consultation process took place on a national level, involving all the key actors, with a special emphasis on local, rural and farming communities. The preparatory notes for setting up a REDD+ strategy were formulated during the first preparatory phase (2010-2013). The workshops that were held during this period were widely attended (182 community representatives, government bodies, manufacturers associations, businessmen, technical experts, and other professionals). The different aspects of the REDD strategy were discussed and collectively defined during this phase: Monitoring, Reporting and Verification (MRV), Causes of deforestation, Legal Framework, Carbon Property and definition of pilot zones. The REDD+ strategy comprises a Gender Component. It is defined in a way as to promote participation. During the second phase of preparation (2014 to now): As part of the REDD + process, the following events took place between 2014 and 2016: • August 2014 R-PP Approval accepted into the readiness fund. March 2015. First SESA National Workshop. • October 2015. Grant Agreement signed and ER-PIN Approved. • June 2016, the Letter of Intent (LOI) was signed. • During 2016, the Technical Management Unit of the project (UTG) was established, the terms of reference were drawn up and the hiring of the required personnel was initiated. The REDD+ Strategic Options and the Emission Reduction Actions were discussed during the creation of the MGAS, wherein environmental and social impacts are identified. Workshops involving key players (309 people) were held as part of the Participation and Consultation plan. Although the restrictions imposed by COVID19 negatively affected the consultation and socialization processes with the different actors of the Reduction of Emissions from Deforestation and Forest Degradation Program (PREDD), the consultation process on the Benefit Sharing Plan (BSP) and its additional criteria was carried out. Key actors from all	**10%**	***10%***	***0%***

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[92] ER-PD Dominican Republic, date of submission or revision: August 14, 2019, can be accessed at the following link: https://www.forestcarbonpartnership.org/system/files/documents/Version%20ERPD%2014-08-2019%20Uncertainty%20correction-Trend%20in%20Ref%20level_rev.pdf

Risk Factor	**Risk indicators**	**Default Reversal Risk Set-Aside Percentage**	**Discount**	**Resulting reversal risk set-aside percentage**
	sectors and producers linked to the Program participated, with a total of 471 people consulted, of which 372 (78.9%) were men and 99 (21.1%) women, in 2020. With the limitations still in place, during 2021 it was possible to hold two meetings with the Technical Advisory Committee (TAC) where 40 representatives from different state, academy and civil society institutions were updated on the status of the preparation phase of the program, the commitments to comply with the ERPA, the signing of the inter-institutional agreements and the transfer of RE agreements, and the formation of the National Benefit Sharing Committee (NBSC). At the end of 2021, the TAC approved the roadmap for the NBSC creation, which is the main governance body and where the beneficiaries and executing entities are represented.			
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	In accordance with Decree No. 269-15 [93], article 3a, the integration and coordination of sectorial, regional, local and national policies, starting with the recognition that public policies and all related plans, programs and project need to be designed and managed bearing in mind the need to adapt to climate change. Furthermore, adapting to and mitigating climate change is established as a transversal policy, to be implemented across the entire National Development Strategy 2030, and coordinated with all other transversal policies, particularly environmental sustainability, risk management, territorial cohesion, and gender equality (Art 4a). Resolution No. 034-2019 was issued in 2019, which institutionalizes the mechanism of the United Nations Framework Convention on Climate Change for the reduction of emissions caused by deforestation and forest degradation (REDD+) and stablishes the Coordination Office for REDD+ in the Ministry of Environment and Natural Resources. In 2020, Decree 540-20 National System for Measurement, Reporting and Verification of Greenhouse Gases of the Dominican Republic (MRV) was issued, which strengthens coordination between the different sectors. In its article 4 stablishes that: The National MRV System has as its fundamental objective the inter-institutional coordination of the different reports that are prepared to make transparent the emissions of greenhouse gases generated at the national level, as well as the establishment of mitigation measures of greenhouse gas emissions and the support and financing received for climate action.	**10%**	***5%***	***5%***
Lack of long term effectiveness in addressing underlying drivers	Recent improvements in Dominican legislation have given environmental issues exposure on a national level and have inspired environmental conservation projects. In addition to the Emissions Reduction Program Actions, the agricultural sector has economic instruments at its disposal that contribute to breaking the connection between economic ventures and deforestation, for example: i. Resolution No. 10-08 issued by the Ministry of the Environment created the Payment for Environmental Services (PSA) program, which purports to set up the National Compensation System for the conservation of woodland or agroforestry systems that protect the soil in water-catchment areas. ii. The "Climate Change National Policy" (PNCC) document, drafted by the Ministry for the Economy, Planning and Development, in collaboration with the Ministry for the Environment, foresees the establishment of a National Carbon and Climate Change Fund (FONCAC). This fund is aimed at financing climate change adaptation activities, including in the farming sector. Such activities include: a) paying small farmers for environmental	**5%**	***5%***	***0%***

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[93] Dec. No. 269-15 establishing a National Climate Change Policy Repeals Decree No. 278-13. G. O. No. 10813 of 2 October 2015.

Risk Factor	**Risk indicators**	**Default Reversal Risk Set-Aside Percentage**	**Discount**	**Resulting reversal risk set-aside percentage**
	and ecosystemic services designed to tackle deforestation and protect biodiversity; b) granting rural credits in exchange for compliance with environmental conditions set out in management plans; and c) offering favourable interest rates and guarantees for environmental projects[94]. iii. During 2020, Decree 540-20 stablished the National System for the Measurement, Reporting and Verification (MRV) of Greenhouse Gases of the Dominican Republic, in order to account for greenhouse gas emissions and execute mitigation actions to guarantee financing aimed at promoting climate action. iv) In 2021, Decree No. 627-21 was issued, approving the Regulations of the Forestry Sector Law No. 57-18, which complements the application of this law. v) The National REDD+ 2022-2036 Strategy was prepared, whose objectives are: i) Promote sustainable forest management, ii) Increase the resilience of forest ecosystems against the effects of climate change, iii) Contribute to the improvement of quality of life of the population, through goods and services from forests and agroforestry systems, iv) Reduce greenhouse gas emissions caused by deforestation and forest degradation, and v) Maintain and/or increase carbon stocks in forests and agroforestry systems.			
Exposure and vulnerability to natural disturbances	Due to its geographical location, the country is permanently exposed to hurricanes and heavy rain that seriously damage the vegetation and associated resources. Between 1930 and 2007, the Dominican Republic was very badly affected by 8 high-intensity hurricanes. The 2021 hurricane season was the sixth consecutive season since 2016 where the climatological average for tropical cyclone formation has been exceeded. For the Dominican Republic we were affected by: Hurricanes Elsa and Grace, and Tropical Storm Fred. According to the reports of the Central Bank, by sectors, the most vulnerable to hurricanes, storms and droughts are agriculture, tourism and mining, whose income is equivalent to 14.6% of GDP. "After a climatic event, agricultural production is reduced, the hotel infrastructure is affected and the entry of tourists to the country decreases." The COVID-19 pandemic negatively affected the country. However, during 2021 a growth of 12.3% of GDP was achieved, due to the timely response of the government, as well as an effective vaccination campaign.	5%	*0%*	*5%*
		Total reversal risk set-aside percentage		*20%*
		Total reversal risk set-aside percentage from ER-PD or previous monitoring report (whichever is more recent)		*20%*

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[94] De los Santos, J., Muñoz, G., Egas, J. J., De Salvo, C. P., & Schmitd, T. D. (2018). Farming Policies, DR-CAFTA and Climate Change in the Dominican Republic

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

Quantify the emission reductions available for transfer to the Carbon Fund by completing the white cells in the table below. Additional columns may be added if the country wishes to report in separate calendar years. If it does not wish to report per calendar years, the FCPF units will be distributed per calendar years pro-rata to the number of years at the time of issuance. Separation in calendar years is only applicable if the Emission Reductions in all the years of the Reporting Period is positive.

If the Program Entity wishes to report additional ERs for a Reporting Period it has already reported for as a result of increased ability to transfer ER title, it shall only present below the FCPF units corresponding to the additional number of ERs for which the ability to transfer Title to ERs is clear and uncontested.

A.	**Emission Reductions during the Reporting period (tCO$_2$-e)**	*from section 4.3*	**1,880,282**
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)**		-
C.	**Number of Emission Reductions estimated using measurement approaches (A-B)**		1,880,282
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*	-
F.	**Total ERs (B+C)*D-E**		1,880,281
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*	15%

H.	**Quantity of ERs to be allocated to the Uncertainty Buffer (0.15*B/A*F)+(G*C/A*F)**		282,042	–
I.	**Total reversal risk set-aside percentage applied to the ER program**	*from section 7.3*	20%	
J.	**Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)**		239,736	
K.	**Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*5%**		79,911	
L.	**Number of FCPF ERs (F- H – J – K)**		**1,278,592**	

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

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I. Requirements of FCPF on Managing the Environmental and Social Aspects of ER Programs

“Programmatic Element 3: Safeguards

The ER Program meets World Bank social and environmental safeguards, promotes and supports the safeguards included in UNFCCC guidance related to REDD+, and provides information on how these safeguards are addressed and respected, including through the application of appropriate grievance mechanisms."

“Programmatic Element 4: Stakeholder participation

The design and implementation of ER Programs is based on and utilizes transparent stakeholder information sharing and consultation mechanisms that ensure broad community support and the full and effective participation of relevant stakeholders, in particular affected Indigenous Peoples and local communities.”

See Criterion 24 and 25 of FCPF Methodological Framework

- The General Conditions Applicable to Emission Reductions Payment Agreements (EPRAs), Section 5.01(b)(i), requires the Program Entity to “*provide evidence satisfactory to the Trustee that the ER Program Measure(s) are being implemented in accordance with the Safeguards Plans*” as an annex to the ER Monitoring Report.

- The General Conditions Applicable to ERPAs, Section 16.01(vii), also provides that “*failure to observe, implement and meet all requirements contained in . . . a Safeguards Plan provided for under the ERPA (including any feedback and grievance redress mechanism provided for under the ER program, the Benefit Sharing Plan and/or a Safeguards Plan)*” is considered an Event of Default on the part of the Program Entity.

- The ERPAs include an additional covenant requiring the Program Entity to “monitor and report to the Trustee on the implementation of the Safeguards Plans (…) during Reporting Periods. The Program Entity shall monitor and report to the Trustee on the implementation of the Safeguards Plans annually after the date of this [ERPA]. (…) The Trustee reserves the right to initiate a separate monitoring of the implementation of the Safeguards Plans (…) annually after the date of this [ERPA] by an independent Third Party monitor.”

- Annex 1 is the primary tool for the Program Entity to provide evidence on whether the ER Program has been implemented in accordance with the Safeguard Plans. The World Bank, in its capacity as Trustee of FCPF, will review information provided in this Annex to confirm whether the Safeguards

Plans have been complied with and whether the management of the environmental and social aspects of the ER Program warrants any corrective actions.

- The specific content of Annex 1 should be based on the specific requirements in the Safeguards Plans of the ER Program. In general, information for Annex 1 should be collected from desk review of relevant documentation,[95] interviews with staff and program stakeholders, and field visits.

- The status of the implementation of the Safeguards Plans often cannot be measured by quantitative indicators. Therefore, the content in Annex 1 should be mostly presented in a narrative form and, where relevant and illustrative, supporting quantitative information could be included

- Reporting should focus on the overall performance of the management measures to implement the Safeguards Plans, supplemented by examples of good practice or non-compliance with the Safeguards Plans.

II. Monitoring and Reporting Requirements

1. **Entities that are responsible for implementing the Safeguards Plans are adequately resourced to carry out their assigned duties and responsibilities as defined in the Safeguards Plans.**

1.1 Summarize the key institutional arrangements, such as decision procedures, institutional responsibilities, budgets, and monitoring arrangements that are required under the Safeguards Plans.

1.2 Confirm whether the institutional arrangements summarized above have been put in place.

1.3 Confirm that the implementing entities and stakeholders understand their respective roles; have the technical capacity to execute their responsibilities; and have adequate human and financial resources.

1.4 Where specific capacity building measures (e.g., training and professional development) have been required by the ER Program or Safeguards Plans, describe the extent to which these measures have been carried out.

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[95] Documentation that the Program Entity should review include operational monitoring reports prepared by the Program Entity, environmental and social plans prepared during Program implementation (e.g., Environmental and Social Management Plans (ESMPs), Resettlement Action Plans (RAPs), Indigenous Peoples Plans (IPPs)), and other relevant records (e.g., records produced under the Feedback and Grievance Redress Mechanism, as available).

2. ER Program activities are implemented in accordance with management and mitigation measures specified in the Safeguards Plans.

2.1 Confirm that environmental and social documents prepared during Program implementation are based on the Safeguards Plans. Provide information on their scope, main mitigation measures specified in the plans, whether the plans are prepared in a timely manner, and whether disclosure and consultation on the plans are carried out in accordance with agreed measures.

2.2 Confirm if entities responsible for implementing the Safeguards Plans maintain consistent and comprehensive records of ER Program activities such as records of administrative approvals, licenses, permits, documentation of public consultation, documentation of agreements reached with communities, records of screening process, due diligence assessments, and records of handling complaints and feedbacks under the Feedback and Grievance Redress Mechanism (FGRM).

2.3 Summarize the extent to which environmental and social management measures set out in the Safeguards Plans and any subsequent plans prepared during Program implementation are implemented in practice, the quality of stakeholder engagement, as well as whether field monitoring and supervision arrangements are in place.

2.4 Confirm that the FGRM is functional, supported with evidence that the FGRM tracks and documents grievances, is responsive to concerns, complaints or grievances.

3. The objectives and expected outcomes in the Safeguards Plans have been achieved.

3.1 Assess the overall effectiveness of the management and mitigation measures set out in the Safeguards Plans.

3.2 Are the arrangements for quality assurance, monitoring, and supervision effective at identifying and correcting shortcomings in cases when ER Program activities are not implemented in accordance with the Safeguards Plans?

3.3 Describe the supervision and oversight arrangements to ensure that the Safeguards Plans and, if any, subsequent environmental and social documents prepared during Program implementation are implemented. Are these supervision and oversight arrangements effective (e.g., provide meaningful feedback mechanism to implementing entities to allow for corrective actions)?

4 Program activities present emerging environmental and social risks and impacts not identified or anticipated in the Safeguard Plans prepared prior to ERPA signature.

4.1 Is the scope of potential risks and impacts identified during the SESA process continue to be relevant to ER Program activities?

4.2 During implementation, has any ER Program activities led to risks or impacts that were not previously identified in those Safeguard Plans prepared prior to ERPA signature? If so, what are the proposed actions to manage such risks and impacts that were not anticipated previously?

5. **Corrective actions and improvements needed to enhance the effectiveness of the Safeguards Plans.**

5.1 Provide a self-assessment of the overall implementation of the Safeguards Plans

5.2 List any corrective actions and areas for improvements. Take care to distinguish between: (i) corrective actions to ensure compliance with the Safeguards Plans; and (ii) improvements needed in response to unanticipated risks and impacts

5.3 Describe the timeline to carry out the corrective actions and improves identified above.

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

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I. Requirements of FCPF on Benefit Sharing Plans

Programmatic Element 5: Benefit sharing

The ER Program uses clear, effective and transparent benefit-sharing mechanisms with broad community support and support from other relevant stakeholders.

See Criterion 29; 30; 31; 32; 33 of FCPF Methodological Framework

- The General Conditions Applicable to Emission Reductions Payment Agreements (EPRAs), Section 5.01(b)(i), requires the Program Entity to "*provide evidence satisfactory to the Trustee . . . that the Benefit Sharing Plan has been implemented in accordance with its terms*" as an annex to the ER Monitoring Report.

- The General Conditions Applicable to ERPAs, Section 16.01(vii), also provides that "*failure to observe, implement and meet all requirements contained in . . . the Benefit Sharing Plan . . . provided for under the ERPA (including any feedback and grievance redress mechanism provided for under the ER program, the Benefit Sharing Plan and/or a Safeguards Plan)*" is considered an Event of Default on the part of the Program Entity.

- The Methodological Framework, Criterion 32, requires that information on the implementation of the BSP is disclosed publicly.

- The ERPAs include an additional covenant requiring the Program Entity to "*monitor and report to the Trustee on the implementation of (…) the Benefit Sharing Plan during Reporting Periods (…) The Program Entity shall first monitor and report to the Trustee on the implementation of the Benefit Sharing Plan six (6) months after receipt of the first Periodic Payment and annually thereafter. The Program Entity may coordinate the annual monitoring and reporting of the Safeguards Plans and the Benefit Sharing Plan, provided that the Program Entity notifies the Trustee and the Trustee accepts such coordinated timelines. The Trustee reserves the right to initiate a separate monitoring of the implementation of (…) the Benefit Sharing Plan annually after the date of this [ERPA] by an independent Third Party monitor.*"

- Annex 2 is the primary tool for the Program Entity to provide evidence on whether the BSP has been implemented in accordance with the terms of the BSP.

- The specific content of Annex 2 should be determined based on the terms of the BSP. In general, Annex 2 should address: (i) what the agreed commitments in the BSP are; (ii) To what extent have these commitments been met; (iii) whether the agreed benefit sharing arrangements in the BSP are effective; and (iv) whether any aspects of the BSP should be changed to ensure that the agreed commitments will be achieved.

- Annex 2 should provide a synthesis of existing monitoring data collected as part of the implementation of the BSP. It is based on regular self-reporting of the Program Entity as supplemented from time to time by findings of World Bank supervision missions and independent third party monitoring initiatives including field visits, key informant interviews or periodic performance audits.

II. Monitoring and Reporting Requirements

1. Benefit Sharing Plan Readiness

1.1 Confirm that the BSP has been completed and endorsed by all relevant parties. Are there any aspects of the BSP which remain unclear or require further review of endorsement by beneficiaries or other stakeholders? Has the BSP been made publicly available?

1.2 In cases where capacity building initiatives have been included as part of the BSP, confirm whether the Program Entity has completed required capacity building measures to ensure system effectiveness. What other measures are still outstanding?

1.3 Where relevant, confirm whether any agreed changes to the benefit sharing arrangement identified during the previous reporting period have been completed.

2. Institutional Arrangements

2.1 Confirm that the agreed institutional arrangements under the BSP are in place and that implementing entities are appropriately resourced to carry out their respective responsibilities.

2.2 Confirm that any regulatory or administrative approvals required for implementing the BSP have been obtained.

2.3 Assess whether all BSP stakeholders (beneficiaries and administrators) clearly understand their obligations, roles and responsibilities associated with the BSP. This assessment could be based on, for example, findings and feedback received during field implementation support missions, during interviews with beneficiaries, issues raised through public consultation meetings, beneficiary monitoring or grievance mechanisms.

2.4 Confirm that a system is in place for recording the distribution of benefits and associated obligations to eligible beneficiaries. For example, are payment information systems, payment tracking and monitoring systems, bank accounts, accounting and financial control mechanisms, and payment modalities in place and functional?

2.5 Confirm that agreed accountability mechanisms are in place and functional (e.g., stakeholder participation arrangements; agreed public information disclosure procedures; independent third party monitoring and or performance audit mechanisms; dispute resolution and grievance redress mechanisms.)

2.6 Confirm that the Feedback and Grievance Redress Mechanisms (FGRM) is functional to record and address feedback and grievances related to the implementation of the BSP. Confirm the number and types of grievance received and submitted to the FGRM and how and whether they were addressed.

2.7 Confirm that adequate human and financial resources have been allocated or maintained for implementing the BSP.

3. Status of Benefit Distribution

3.1 Summarize the distribution of all monetary and non-monetary benefits during the reporting period.

3.2 Indicate in a table format the number and type of beneficiaries who received benefits during the reporting period (examples of tables to be used and expanded upon below). The tables should include information on:

- the type of benefits distributed, including monetary or non-monetary benefits
- the criteria for distributing the benefits
- the processes and timeline for distributing the benefits (e.g., whether the benefits are distributed one-time or continuous/periodic)
- who the beneficiaries are, including a break-down of the beneficiaries by gender, civil society organizations (CSOs), Indigenous Peoples, and local communities.
- any specific agreements signed with the beneficiaries for them to receive the benefits, and the key terms of such agreements

	Number of people		
	Monetary	**Non-monetary**	**TOTAL**
Men			
Women			
TOTAL			

	% of monetary benefits shared
Men	
Women	
TOTAL	

	% of monetary benefits shared
CSOs	

IPs	
Local Communities	
TOTAL	

3.3 Do beneficiaries receive adequate implementation support to assist in the management and use of benefits distributed to them?

3.4 Describe and assess the effectiveness of the mechanisms for ensuring transparency and accountability during the implementation of the BSP, such as participatory monitoring by beneficiaries.

3.5 Assess whether Benefit Sharing distributions continue to be relevant to core objectives and legitimacy of the ER Program objectives (e.g., benefit sharing is considered equitable and effective; seeks active participation of recipients; is respectful of customary land rights; enjoys broad community support of Indigenous People; benefit distributions incentivize adoption of emission reduction measures, among others).

3.6 Describe the mechanisms that are in place to verify how benefits are used and whether those payments provide sufficient incentive or compensation to participate in program activities to change land use or reduce carbon emissions. To what extent are distribution mechanisms viewed as credible and trusted by beneficiaries?

3.7 Do beneficiaries understand their continued obligations once benefit distribution has taken place? Is there any evidence that there is a mismatch of expectations among beneficiaries regarding the nature and value of benefits accruing to them? What mechanisms are in place to manage such risks?

4. Implementation of the Environmental and Social Management Measures for the BSP

4.1 Assess to what extent the measures for managing the environmental and social aspects of BSP activities have been implemented. Refer to applicable sections in the Safeguards Plans where relevant.

5. Recommendations for BSP Improvement or Modifications.

5.1 Based on experience during the current reporting period as well as feedback from recipients, identify any specific recommendations for modifying the procedural or substantive content of the BSP, if necessary. Substantive changes may include modifications to eligible beneficiaries; rationale or justification for benefits sharing; form or modality of benefit distribution; structure of dedicated funds established to distribute benefits; obligations of recipient among others.

5.2 Are there procedural or administrative obstacles to timely distribution of benefits (e.g., adequacy of financial channels, ability to use funds)? Are benefits distributed in a timely manner?

5.3 Is there evidence of other emerging risks that may affect the sustainability or effectiveness of the BSP?

5.4 Provide a suggested timeline and an outline of administrative arrangements to introduce any recommended changes.

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

Intentionally left blank.

ER programs should review potential Non-Carbon Benefits, identifying a set of priority Non-Carbon Benefits and report on the generation or enhancement of such priority Non-Carbon Benefits. The priority Non-Carbon Benefits should culturally appropriate, and gender and inter-generationally inclusive, as relevant.

*Refer to **criterion 34 and 35** of the Methodological Framework*

Priority Non-Carbon benefits

1. List the **identified set of priority Non-Carbon benefits** and provide necessary details on activities for generation and enhancement of these Non-Carbon benefits. (See questions in sections 2 and 3 below for examples of details on potential specific non-carbon benefits identified)

Priority Non-Carbon Benefit	• Details on activities for generation and enhancement ○ Approach (as defined in ERPD including relevant indicators)
…	…

Other Non-Carbon benefits and additional information as linked to Monitoring and Evaluation Framework

The following indicators are to meet the monitoring requirements within the revised M&E Framework as endorsed at PC25 to be measured through the ER-Monitoring template.

*Refer to **Annex 4** of the FCPF Monitoring and Evaluation Framework March 2018*

2. If applicable linked to **any other (non-priority identified) Non-Carbon benefits**, or if not already covered above linked to Priority Non-Carbon benefits, provide the following additional details:

<u>Livelihood enhancement and sustainability</u>

2.1. Is your CF program testing ways to sustain and enhance livelihoods (e.g. one of your program objective/s is explicitly targeted at livelihoods; your approach to non-carbon benefits explicitly incorporates livelihoods)?

Biodiversity

2.2. Is your CF program testing ways to conserve biodiversity (e.g. one of your program objective/s is explicitly targeted at biodiversity conservation; your approach to non-carbon benefits explicitly incorporates biodiversity conservation)?

Protected/conserved areas

2.3. What amount (in ha) of protected or conserved areas are included in your CF program area? Has this amount increased or decreased in the last year? If so, by how much?

Re/afforestation and restoration

2.4. Total forest area re/afforested or restored through program

Finance and Private Sector partnerships

2.5. Update on CF program budget (as originally presented in ERPD), with updated detail on secured (i.e. fully committed) finance, in US$

2.5.1. Detail the amount of finance received (including ER payments) in support of development and delivery of your CF program. Figures should only include secured finance (i.e. fully committed): ex ante (unconfirmed) finance or in-kind contributions should not be included:

Amount (US$)	**Source** (e.g. FCPF, FIP, name of gov't department)	**Date committed** (MM/YY)	**Public or private finance?** (Delete as appropriate)	**ERP, grant, loan, equity or other?** (Delete as appropriate)
$			Public / Private	ERP / Grant / Loan / Equity / Other
$			Public / Private	ERP / Grant / Loan / Equity / Other
$			Public / Private	ERP / Grant / Loan / Equity / Other

$			Public / Private	ERP / Grant / Loan / Equity / Other
$			Public / Private	ERP / Grant / Loan / Equity / Other
$			Public / Private	ERP / Grant / Loan / Equity / Other

2.5.2. Not including ER payments from the FCPF Carbon Fund, what is the value of REDD+ ER payments that your CF projects have received, and that your country has received overall?

	Total REDD+ ER payments received to date ($US)
Carbon Fund project/s (i.e. ER payments from sources other than the Carbon Fund)	$
All other national REDD+ projects	$

2.5.3. How many formal partnerships have been established between your CF program and private sector entities? Formal partnerships are defined as:

- The partnership is based on a written MoU (or equivalent), and/or
- The partnership involves tangible financial exchange/s, and/or
- The partnership involves tangible non-financial exchange/s (e.g. in-kind contributions)

	Established in the last year (Jul-Jun)	**Total to date**
Number of private sector partnerships involving financial exchange		
Number of private sector partnerships involving non-financial exchange		

3. Other Non-Carbon benefits and additional information

Any other activities that generate or enhance non-carbon benefits in addition to those listed as earlier priority or those that are required for the Monitoring and Evaluation Framework

Policy development

3.1. Is your CF program involved in the development, reform and/or implementation of policies to help institutions/people/systems/sectors? Please provide information on the approach and any other relevant or related indicators/results.

Capacity building

1.1. Is your CF program involved in training, education or provision of capacity building opportunities to increase the capacity of institutions/people/systems? Please provide information on the approach and any other relevant or related indicators/results.

Other

3.2. Is your CF program involved in generation or enhancement of any non-carbon benefits not already covered in this annex? Please provide information on the approach and any other relevant or related indicators/results.

ANNEX 4: CARBON ACCOUNTING - ADDENDUM TO THE ERPD

Technical corrections

The provisional inclusion of the Dominican Republic's Emission Reductions Program Document (ER-PD) into the portfolio of both Tranche A and Tranche B of the Carbon Fund was deemed approved upon fulfillment of the submission of a document to the Facility Management Team (FMT) detailing any proposed additional technical corrections to be made to the Reference Level before the first verification. In September 2019, the Dominican Republic presented a technical and methodological proposal responding to the conditions pointed out in resolution CFM/20/2019/5[96]. The Technical Corrections Proposal addressed the following improvements:

4. Biennial data on deforestation of primary and secondary forest, degradation, restoration, deforestation, all data on a pixel basis wall-to-wall.
5. Monitoring and emission factors of soil organic carbon using a considerably improved methodological approach, especially given the significance of soil carbon in mangroves; and
6. Estimation of separate emission factors for the secondary and primary forest.

In response to the comments of the Chair summary report, a stepwise approach was used to update the reference level for the period 2006-2015. The technical corrections applied to the original Reference Level have been made following this technical and methodological proposal. All the technical modifications are in line with paragraph 2 of the "Guideline on the application of the methodological framework Number 2: Technical corrections to GHG emissions and removals reported in the reference period". Technical corrections do not compromise the consistency of GHG emissions and removals estimates between the Reference Period and monitoring periods, as both calculations apply the improvements. None of the improvements relate to a change in policy and design decisions affecting the Reference Level. Carbon pools and gases, GHG sources, reference period, forest definition, REDD+ activities, Accounting Areas, forest types remain unchanged.

Activity data on deforestation of primary and secondary forests and restoration: Corrections to historical activity data result from the use of reference data of higher spatial and temporal resolution than the one used at the time of submission of the final ER-PD. The methods used to estimate activity data are aligned with IPCC and GFOI guidance and guidelines.

Before deciding on using sampling-based estimates, deforestation and regeneration activity data based on pixel-based wall-to-wall was assessed. It was evaluated the option of using activity data calculated from the geographic comparison of biennial Forest Cover (FC) maps produced by TerraPulse for the Dominican Republic. TerraPulse developed biennial satellite-derived (FC) maps applying data extraction and automatic learning algorithms to large volumes of satellite images to monitor deforestation, reforestation, degradation, and forest recovery.

Based on biennial FC maps, a land-use change map was prepared for the Reference Period 2005 to 2015. This map was validated following Olofsson's (2014) guidelines[97]. A systematic grid of 7,697 sampling points (2.5*2.5 km) was used to obtain reference data for the validation process. The land-use change map includes the following categories: Lakes and other water bodies (CUERPOSAGUA), Forest land remaining as forest since 2001 (B2001), Non-Forest converted to forest lands (BSEC), Forest land converted to non-forest lands (DEFOB2001), Secondary Forest converted to non-forest lands (DEFOBSEC), and Non-Forest lands remaining as non-forest lands (NOBOSQUE).

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[96] The Technical and Methodological Proposal Responding to the Conditions Pointed out in Resolution CFM/20/2019/5 can be accessed at the following link: https://www.forestcarbonpartnership.org/system/files/documents/DR_Technical%20note%20Responding%20to%20the%20Conditions%20Pointed%20out%20in%20Resolution%20CFM2020195.pdf

[97] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

All estimates of Land-use transitions and stable classes based on TerraPulse data fell outside the confidence intervals of the sampling-based estimates. According to the land-use change validation (see Table 4.1), deforestation and regeneration activity data based on pixel-based wall-to-wall maps present significant bias. The bias is above 47% for all land-use transitions except for permanent forests (B2001). Therefore, option 3 of the Technical and Methodological Proposal responding to the conditions in Resolution CFM/20/2019/5 was used to estimate stable land-use classes and land-use transitions.

Only sampling-based estimates and associated uncertainties were used to calculate the activity data. Annual activity data for deforestation and forest regeneration were derived from the sampling procedure (7,697 sampling grid), where years of transitions were recorded for each point.

Table A4.1: Validation of the land-use change map 2006-2015.

Category of land-use change for the period 2006-2015	code	Number of samples	Producers' accuracy	Users' accuracy	Map pixel count area (ha)	Sampling random estimate (ha)	90% Confidence interval (ha)	Map area fall inside CI	Bias
Lakes and other bodies of water	CUERPOSAGUA	113	0.88	0.85	72,130	70,834	10,881	Yes	1.80%
Forest land remaining as forest since 2001	B2001	2759	0.68	0.73	1,639,993	1,729,469	43,378	No	-5.46%
Non-Forest converted to forest lands	BSEC	406	0.36	0.14	642,975	254,500	20,222	No	60.42%
Forest land converted to non-forest	DEFOB2001	160	0.26	0.06	460,947	100,295	12,907	No	78.24%
Secondary Forest converted to non-forest lands	DEFOBSEC	3	0.67	0.01	204,890	1,881	1,786	No	99.08%
Non-Forest lands remaining as non-forest lands	NOBOSQUE	4253	0.59	0.86	1,802,019	2,665,977	44,972	No	-47.94%

Forest degradation activity data: Activity data used to calculate emissions and removals due to degradation and canopy recovery in forest remaining forests were also determined with sampling-based estimates (7,697 systematic grid). Canopy cover category maps for 2005 and 2015 were prepared, including three classes: 30-60%, 60-85%, and >85%. Canopy cover change map 2006-2015 was prepared from terraPulse FC maps considering only pixels with canopy cover probability of 90% or above. Both maps were geographically compared to obtain the canopy cover change map 2005-2015, including the following classes: i. Lakes and other bodies of water, ii. Stable Forest, iii. Forest with degraded canopy cover, iv. Forest with canopy cover recovery and v. non-Forest lands and Secondary Forest.

Table A4.2 compares the pixel count area of the canopy cover change map with the random sampling estimate based on 2,083 sampling points reference data. Reference data were based on the interpretation of high-resolution imagery. The canopy cover change map overestimates canopy cover transitions (more than 52% bias). However, the Stable Forest bias is 14%.

Considering that data based on pixel-based wall-to-wall could overestimate activity data, sampling-based estimates were used to determine degradation and canopy recovery (using 7,697 systematic grid). Also, considering that FC maps provide a more robust determination of Canopy Cover than high-resolution imagery interpretation, forest cover and its probability were extracted from FC maps for each sampling point located in a permanent forest in the systematic grid. This information made it possible to assign each point the canopy cover class 30-60%, 60-85%, and >85% for the later analysis of canopy cover change.

Table A4.2. Validation of the canopy cover change map 2006-2015.

Category of canopy cover change for the period 2006-2015	code	Number of samples	Producers' accuracy	Users' accuracy	Map pixel count area (ha)	Sampling random estimate (ha)	90% Confidence interval (ha)	Map area fall inside CI	Bias
Lakes and other bodies of water	CUERPOSAGUA	9	0.78	0.78	71,824.50	21,238.81	11,620.27	No	70%
Stable forest	ESTABLE	355	0.42	0.46	733,270.41	837,753.05	66,484.40	No	-14%

Forest with degraded canopy cover	DEGRADADO	40	0.15	0.06	249,131.97	94,394.71	24,310.27	No	62%
Forest with canopy cover recovery	RECUPERACION	97	0.24	0.12	477,467.91	228,907.17	37,314.42	No	52%
Non-forest lands and Secondary Forest	NOBOSQUEYREGENERACION	1542	0.82	0.91	3,289,515.03	3,638,916.08	75,488.44	No	-11%

Revised methodological approach for estimating the annual stock change of Soil Organic Carbon (SOC): The annual change in the SOC pool estimate was technically corrected. The updated SOC pool change calculation is now based on Equation 2.25 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. SOC emissions associated with deforestation now include the land-use changes occurring in the Reference Period and the emissions resulting from land-use changes in previous years ("legacy emissions"). Full implementation of this approach was possible since a long time series of deforestation activity data was available based on 1984-2021 annual FC maps that let going back at least 20 years before the start of the Reference Period to estimate legacy emissions correctly.

It was assumed that the Soil Organic Carbon stock change during the transition to a new equilibrium SOC occurs linearly over 20 years. The Land Units represent yearly classes from the land-use change analysis used in setting the reference level. Also, Land Units maintain the same forest types as those used in the land-use change analysis provided in the ER-PD.

Additionally, new SOC values (before and after forest transition) were collected to replace the original estimates sourced from National Forest Inventory. The soil organic carbon pool estimates in the NFI of the Dominican Republic presented errors and methodological limitations. NFI soil samples were collected from the upper 15 cm of soil. However, the soil organic carbon stock was calculated from the upper 30 cm. Generally, the SOC decreases with sampling depth. Also, the gravel content was ignored during the SOC pool calculation. Rock fragments do not have organic carbon, and the coarse stone percentage is sometimes very high. Calculate SOC at 30 cm using soil values taken at 15cm, and without considering the coarse volumetric ratio, overestimate the pool of SOC and, consequently, the deforestation emission factor.

To avoid the overestimation of SOC, two hundred sixty paired plots were established (130 in forest lands and 130 in non-forest use) to measure Soil Organic Carbon before and after deforestation, comparing the SOC between pairs by type of vegetation. Inventory plots were evenly distributed in landscape units according to soil type and land use. The soil was sampled at 15 cm and 30 cm depth in paired plots established for each landscape unit. Soil organic carbon stock (SOCS) was computed as the product of three variables, organic carbon content (SOC), bulk density (BD), and stoniness (S). Soil organic carbon stock (SOCS) was calculated with the following equation:

$$SOCS_i = SOC_i \times BD_i \times D(1 - S_i)$$ Equation A4.1

Where SOC is the soil organic carbon concentration percentage (g $100g^{-1}$), BD is bulk density (g cm^{-3}), D is the thickness of the layer (30 cm), and S is the proportion of the volumetric coarse fragments fraction (g g^{-1}).

Finally, SOC stocks were compared between paired plots (forest cover and non-forest land-use) to estimate the carbon stock change for each transition. The exchange rate of SOC was also calculated, considering the time elapsed from deforestation based on the land-use history of the plot determined by interviewing the landowner and, where possible, validated with time-series satellite imagery.

Estimation of separate emission factors for the secondary and permanent forest:

TerraPulse developed annual forest cover maps based on the canopy cover and probability of change in forest cover from one year to another. This information offers long-term and consistent mapping and monitoring of forest cover. It allows the retrieval of historical reference scenarios from the satellite records and the detection of deforestation, degradation, and growth over time. Based on FC maps, a forest cover change analysis was prepared considering only pixels with> 90% probability of having a forest cover higher than 30%, 60% and 85%. Subsequently, forest degradation classes and secondary forest cohorts were mapped into four categories: i. Intact forest (>85% crown cover), ii. Degraded forest (60-85% crown cover), iii. Highly degraded forest (30-60% crown cover) and Secondary forest.

All forest inventory plots in forest and tree-shaded crops were classified into four categories based on terraPulse data. By forest type and degradation class, carbon content was directly derived from the biomass sampling plots database (average and 90%CI). The mean annual increment of secondary forest and tree-shaded crops (tC/ha/yr.) was estimated by dividing standing biomass by the age determined from the forest cover change maps. In secondary forest types with less than ten sampling plots, additional forest plots were inventoried. A series of 32 secondary sampling units were inventoried in 2021, and age was determined from different sources: interviews and satellite information and secondary data. The standing biomass of these plots was divided by age to estimate mean annual increment rates (tC/ha/yr.).

Start Date of the Crediting Period

The start of the Crediting Period[98] must coincide with the start date of the first Reporting Period under the ER Program. According to the Minimum Reporting Periods Amounts in Schedule 2 of Emission Reductions Payment Agreement, the first Reporting Period start the ERPA´S agreement date. ERPA signature was on March 1st, 2021.

This date meets the definition of the Start Date of the Crediting Period provided in the FCPF Glossary of Terms as follows:

- The start date is not earlier than the date first ER Program Measures begins generating ERs.
- This was confirmed by signing of the ERPA and resulted in this date being the start date in the ERPA
- It is not earlier than January 1st 2016.
- It does not fall within the Reference period 2006-2015.

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[98] Crediting Period Start Date: Also known as 'ER Program Start Date' under the FCPF ERPA General Conditions, is the start date of the first Reporting Period under the ER Program. (Forest Carbon Partnership Facility – Carbon Fund, 2020. Glossary of Terms. Version 1.)

7. CARBON POOLS, SOURCES AND SINKS

7.1 Description of Sources and Sinks selected

All significant sources and sinks are included in the Reference Level.

Table A4-7-0-1: Activities included in the reference level

Sources/Sinks	Included?	Justification/Explanation
Emissions from deforestation	Yes	Deforestation is the main source of forest emissions. The annual emissions average from this source is 2,523,765 tones CO2e*year^{-1}.
Emissions from forest degradation	Yes	Emissions from forest degradation are estimated using the best data available, following the indication of the Carbon Fund Methodological Framework indicator 3.3. Emissions from forest degradation are calculated based on the estimate of the change in percentage of canopy cover, in stable forest. Tree-canopy cover was estimated through an automatic learning algorithm based on remotely sensed variables. The annual emissions average from this source is 1,325,494 tones CO2e*year^{-1}.
Enhancement of carbon stocks in forest remaining forest	Yes	Carbon removal due to the recovery of canopy cover in the forest lands remaining as a forest is estimated with the same methodology used to calculate forest degradation emissions. The annual removals average from this source is -2,172,784 tons CO2-e*year-1.
Enhancement of carbon stocks in land converted to forest land	Yes	It includes carbon removal in lands converted to forest land. This estimate does not include the accumulation of carbon in secondary forests that already existed before 2005. Forest plantations are part of this category. The annual removals average from this source is -2,108,803 tons CO_{2-e}*year^{-1}.
Conservation of carbon stocks	No	Carbon emissions and removals in public or private conservation land, or land that is under forest management, are included in the estimations of emissions from deforestation and degradation; they are also included in the calculation of removals in forests that remain as forests and land converted to forest land.
Sustainable forest management	No	

7.2 Description of carbon pools and greenhouse gases selected

Table A4-7-0-2: Carbon pools included in the reference level

Carbon Pools	Selected?	Justification/Explanation
Above Ground Biomass (AGB)	**Yes**	The National Forest Inventory (**NFI**)[99], the Assessment of Biomass and Carbon Content in Non-Forest Cover in the Dominican Republic" (**ISNB**)[100], and the Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic,

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[99] Ministry of the Environment. 2015. Inventario nacional forestal de la República Dominicana: Measure and assess forests in order to understand their diversity, composition, volume and biomass. Field Manual. Forest Monitoring Unit. REDD7CCAD-GIZ. Regional Project 48 pages

[100] Ministry of the Environment. 2017. Assessment of the biomass and carbon content in non-forest systems in the Dominican Republic. Field Manual. Forestry Monitoring Unit REDD+ Preparation Project. 54 pages

		2006-2015 (**Technical Correction Inventory**)[101]. include the estimation of above-ground Biomass for the main types of forest and non-forest uses. According to these inventories, the above-ground biomass represents 78% of Total Biomass (AGB + BGB+ Litter + Deadwood).
Below Ground Biomass (BGB)	**Yes**	Below-Ground Biomass in forests and non-forest systems is calculated using the Cairns equation [102]. The below-ground biomass represents 15% of the Total Biomass (AGB + BGB+ Litter + Deadwood).
Litter	**Yes**	The **NFI**, **ISNB** and the **Technical Correction Inventory** include the assessment of the carbon content in Litter and deadwood. According to these estimations, Litter and deadwood represent 8% of Total Biomass. This information is available for all land cover classes (forest and non-forest). No data are available on changes of Litter and Deadwood over time.
Dead Wood	**Yes**	
Soil Organic Carbon (SOC)	**Yes**	The estimation of soil carbon (SOC) was technically corrected. For the determination of the organic carbon balance of the soil after deforestation in the main types of soil, 260 plots were established in paired forest – non-forest plots. Sampling Plots were located ensuring at least five paired plots in each of the main transitions by soil type that add up to 80% of the area of change observed during the reference period (2006-15). The Soil Organic Carbon Linear decreasing rate was calculated based on the estimate of SOC before and after conversion with Equation 2.25 from the 2006 IPCC Guidelines, Volume 4, Chapter 2

Table A4-7-0-3: Greenhouse gases included in the reference level

GHG	Selected?	Justification/Explanation
CO_2	**Yes**	The ER Program account for CO_2 emissions and removals
CH_4	**No**	The Reference level does not include emissions of non-CO_2 gases resulting from forest fires. The available historic data are spatially explicit and there is no available data on the impact of fires, such as which fuel beds are affected, the % of fuel burned, etc. On the other hand, it is not possible to separately estimate the effect of fires on forest land converted to other use or on forests remaining as forests. Likewise, the CH_4 and N_2O emissions represent 0.06% of the emissions estimated during the reference period (2,523,765 tCO2e*year^{-1}), according to the Third Communication (the CH_4 y N_2O emissions are estimated to be 1,514 tCO2e*year^{-1}).
N_2O	**No**	

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[101]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

[102] Cairns, M. A., Brown, S., Helmer, E. H., Baumgardner, G. A., Cairns, M. A., Brown, S., … Baumgardner, G. A. (1997). Root Biomass Allocation in the World ’s Upland Forests. *Oecologia*, *111*(1), 1–11. http://doi.org/10.1007/s004420050201

8 REFERENCE LEVEL

The Reference Level is established at the national level and includes the emissions and removals produced because of forest land being converted to non-forest land (deforestation) and the conversion of non-forest land to forest land (increase of stocks) and carbon flows in forest lands that remain as forests (emissions from forest degradation and removals from canopy cover recovering).

Table A4-8-1: REDD+ activities considered in the reference level

Reference level	IPCC Categories	Dominican Republic Emissions Reduction Programme Actions
Deforestation	- Forest Land converted into other land (crops and grazing land). ***FL-AL and FL-OL***	3.4. Reducing and/or halting deforestation and degradation in protected areas relevant to the conservation of forest resources. 3.5. Enhancing the programme for protection and surveillance in protected areas relevant to the conservation of forest resources. 3.9. Defining and putting into practice financial instruments and mechanisms for developing activities associated with production, conservation, and restoration of forestry ecosystems.
Degradation	- Forest lands that remain as forest. ***TF-TF***	3.4. To reduce and/or slow down deforestation and degradation in major protected areas for the conservation of forest resources. 3.5. Enhancing the programme for protection and surveillance in protected areas relevant to the conservation of forest resources. 3.7. To establish a system for evaluating and monitoring forest management. 3.8 Promote the management of natural regeneration of tree species among private farms and community organizations. 3.12. Strengthen the phytosanitary protection programme in priority forest areas.
Increase in forest carbon stocks	- Forest lands that remain as such. ***TF-TF*** - Land converted to forest land. ***AL-FL and OL-FL***	3.1. Strengthen reforestation and agroforestry plans and programmes such as the National Quisqueya Verde Plan and the Agroforestry Programme. 3.2. Promoting the incorporation of agroforestry systems for managing agricultural and cattle farms. 3.6. Rehabilitating forest ecosystems in fragile areas relevant for facilitating connectivity between forest fragments. 3.11. Developing the programme for restoring post-fire affected ecosystems.

8.1 Reference Period

The selected reference period is **2006-2015**:

Start date: January 1st, 2006.

End Date: December 31st, 2015.

This reference period was defined during preparing the final draft of the Emission Reduction Program Document (ER-PD). While preparing ER-PD's final draft version, the Ministry of the Environment of the Dominican Republic developed a consistent series of land use maps for 2005, 2010, and 2015 suitable for applying IPCC approach 3. The country decided to define the 2006-2015 reference period, considering the land-use change information available.

Even though the country later prepared a new land-use change analysis for the 2000-2018 period, to be consistent with Criterion 11 (indicators 11.1 and 11.2) of the Methodological Framework of the Carbon Fund, the Government of the Dominican Republic maintained the 2006-2015 reference period.

The reference period's end date must not be more than two years before the TAP starts the independent assessment of the draft ER Program Document and for which forest-cover data is available to enable IPCC Approach 3.

8.2 Forest definition used in the construction of the Reference Level

The development of the reference level uses the following operational definition of forest:

¨Natural or planted ecosystem with biological diversity and enrichment of native species, which produces goods, provides environmental services and social services, whose minimum land surface is 0.5 ha (3x3 pixels measuring 30m), with a tree top coverage that surpasses 30% of the minimum surface, and trees and bushes with the potential to reach a minimum height of 5 meters in their maturity in situ, and 3 meters for dry forest. This definition includes agroforestry systems that fulfil these requirements¨.

This definition differs from the one adopted by the country in the forest resources assessment reports from the FAO[103]. In the 2015 FRA report, the country adopted the following definition of forest:

"Lands extending over more than 0.5 hectares and containing trees of more than 5 meters in height, and with a forest canopy of greater than 10 percent, or containing in-situ trees capable of reaching this height. This does not include land that is predominantly being used for agricultural or urban purposes.

In the operational definition of forest in the ERP, the minimum forest area is greater (0.81 ha), forests with a forest canopy of less than 30% are excluded and this includes tree-shaded agricultural crops. The operational definition of forest needed to be adjusted according to i. the resolution of the satellite images used in land-use mapping (Landsat 30x30m); ii. achieving an appropriate separation of forest and non-forest use categories, and iii. the need to include the carbon stock gains in the reference level as a result of increasing the tree-shaded agricultural crops areas produced during the implementation of the ERP (see action 3.2 in Table A4-8.1).

Differences between the definition of forests are related to limits in canopy cover (FAO uses > 10%, ERPD uses >30%, which may cause a lower estimate of forested area in the ERPD) and the treatment of agroforestry systems that have a tree cover >30%. The area occupied by tree shaded crops has been estimated, including the transitions to and from other cover types over time, this in order to produce data that can be compared transparently between the different reporting systems, such as the FAO and the maps that are used in the country.

Below are the definitions of deforestation, degradation and reforestation considered in the Reference Level estimate:

Definition of deforestation: human-induced elimination of forest canopy cover that exceeds the 30% threshold of canopy cover established in the definition of forest. The elimination of coverage is long-term or permanent, and results in a non-forestry use of the land. Considering that the forest land includes the growth of cocoa, coffee and

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[103] FAO. (2015). GLOBAL FOREST RESOURCES ASSESSMENT 2015 National Report. Dominican Republic.

other fruits, the estimation of emissions due to deforestation includes the transitions of these crops to non-forest land (woody vegetation and non-woody vegetation).

Definition of degradation: human-induced elimination of forest canopy cover that does not go below the 30% threshold of canopy cover established in the definition of forest. The elimination of coverage may be temporary and does not result in a land-use change. The carbon emission due to forest degradation and carbon removals due to canopy recovery is being estimated separately. Likewise, considering that the forest land includes the growth of cocoa, coffee and other fruits, the estimation of emissions due to degradation includes the transitions of tree-shaded crops to natural forest (moist, dry and pine) and vice-versa.

Definition of reforestation: Activities that lead to the conversion of non-forested land to forest: This includes the restoration of forests with a crown cover greater than 30% through natural and artificial means on deforested land. In addition, it includes the establishment of agroforestry systems with tree cover greater than 30% on lands that were previously deforested.

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

Equations and parameters used to calculate GHG emissions and removals are listed below. These equations show the steps from the measured input to the aggregation into final reported values. Changes to the original calculation described in the ER-PD have been highlighted.

Change in total biomass carbon stocks in forest lands converted to other land-use (Deforestation):

Following the 2006 IPCC Guidelines, the change in total biomass carbon stocks forest (land converted to other land-use,) category (ΔC_{B_t}) would be estimated through the following equation:

$$\Delta C_{B_t} = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$ **Equation 11**

Where:

ΔC_{B_t}	Annual change of total biomass carbon stocks during the period, in tC*year^{-1};
ΔC_G	Increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tC per hectare per year;
$\Delta C_{CONVERSION}$	Initial change in carbon stocks in biomass on land converted to another land-use category, in tC per hectare; and
ΔC_L	Decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tC per hectare per year.

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document for applying IPCC Guidelines and guidance in the context of REDD+[104], the above equation will be simplified, and it will be assumed that the change in total biomass carbon stocks (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$). Considering equation 2.16 of the 2006 IPCC GL for estimating ($\Delta C_{CONVERSION}$) the change of biomass carbon stocks during the Reference Period was calculated with the following equation:

$$\Delta C_{B_{RP}} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) \times A(j,i)_{RP}$$ **Equation 12**

Where:

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[104] https://www.reddcompass.org/documents/184/0/MGD2.0_English/c2061b53-79c0-4606-859f-ccf6c8cc6a83

$\Delta C_{B_{RP}}$ Change of biomass carbon stocks during the Reference Period, in tC.

$A(j,i)_{RP}$ Area converted from forest type j to non-forest type i during the Reference Period, in hectares per year.

$$A(j,i)_{RP} = \frac{P(j,i)_{RP}}{N} \times AA$$ **Equation 4.1**

$P(j,i)_{RP}$: Number of points converted from forest type j to non-forest type I during the Reference Period, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program accounting area (in hectares)

In this case, ninety-six forest land conversions are possible resulted from the combinations of the following forest and non-forest types:

Forest type	Non-forest types
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest. Three canopy cover categories: • Intact forest (>85%). • Degraded forest (60-85%), and • Very degraded forest (30-60%) Two cohorts of secondary forest • Cohort 4-21 years, and • Cohort 22-44 years.	Five types of non-forest land are considered: • Cropland. • Grassland. • Settlement; and • Woody vegetation.

<u>Technical corrections applied this parameter</u>: The deforestation activity data was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions.

$B_{Before,j}$ Total biomass of forest type j before conversion/transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type.

<u>Technical corrections applied to this parameter:</u> The original calculation of change in biomass carbon stock only considered biomass density of the forest type, ignoring the forest's degradation condition. Also, this calculus did not consider the stand age. Carbon density in secondary forests varies with age, and primary forests usually present carbon densities higher than secondary. Ignoring forest degradation and forest age in the measure of change in biomass carbon stock overestimates the emission from deforestation. Therefore, total biomass was recalculated for each canopy cover category (>85%, 60-85%, and 30-60%) into each permanent forest type. Also, total biomass was calculated for each forest cohort.

$B_{After,i}$ Total biomass of non-forest type i after conversion, in tons C per ha. This is equal to the sum of aboveground biomass (AGB_{after}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{after}), litter (L_{after}) and death wood (DW_{after}) and it is defined for each of the five non-forest IPCC Land Use categories.

Technical corrections applied to this parameter: Total biomass of non-forest land uses did not consider the same carbon pools included in the $B_{before,j}$. Carbon densities for non-forest IPCC Land Use Categories were recalculated to ensure carbon pools consistency between $B_{after,i}$ and $B_{before,j}$.

Change in the soil organic carbon pool in mineral soils associated with deforestation:

The total carbon stock change estimated in the ERPD was incorrect. It was assumed an EF of only 1/20 of SOC stock for the Reference Period (RP). The Dominican Republic ERPD did not include emissions from SOC of deforested areas before the reference period. A 20-year default legacy period was not used to estimate emissions from SOC of each deforested area during the Reference Period either.

The annual change in the SOC pool was technically corrected. The updated estimate of SOC pool change was made according to the following:

- SOC change was calculated based on Equation 2.25 from the 2006 IPCC Guidelines, Volume 4, Chapter 2.
- SOC emissions associated with deforestation now include the land-use changes occurring in the Reference Period and the emissions resulting from land-use changes that occurred in previous years ("legacy emissions"). Full implementation of this approach was possible since it was available a long time series of deforestation activity data that let going back at least 20 years before the start of the Reference Period to correctly estimate legacy emissions.
- It was assumed that the Soil organic C stock change during the transition to a new equilibrium SOC occurs in a linearly over a period of 20 years.
- The Land Units represent yearly classes from the land use change analysis used in setting the reference level.
- Land Units maintain the same forest types as the ones used in the land use change analysis provided in the ER-PD.

In accordance with the approach provided in the 2006 IPCC Guidelines, the following matrices and Equation 5 were used for determining the annual change in the soil organic pool associated with deforestation:

Land use change matrix

$$\left|\begin{array}{cccccccc}
\text{Land Unit} & \text{Year 1} & \cdots & \text{Year n} & \cdots & \text{Year 20} & \cdots & \text{Year 20+n} \\
\boldsymbol{LU_1} & \mathrm{A(j,i)_{1,1}} & \cdots & \mathrm{A(j,i)_{1,n}} & \cdots & \mathrm{A(j,i)_{1,20}} & & \\
\vdots & & & \vdots & \vdots & \vdots & \vdots & \\
\boldsymbol{LU_n} & & & \mathrm{A(j,i)_{n,n}} & \cdots & \mathrm{A(j,i)_{n,20-n}} & \cdots & \mathrm{A(j,i)_{n,20+n}} \\
\text{Stable Forest} & SF_J & & SF(j)_{n-1} - \sum_{LU=1}^{n} A(j,i)_n & \cdots & SF(j)_{19} - \sum_{LU=1}^{n} A(j,i)_{20} & \cdots & SF(j)_{19+k} - \sum_{LU=1}^{n} A(j,i)_{20+n}
\end{array}\right|$$

$$\times$$

SOC Value for each LU in a particular year

$$\left|\begin{array}{cccccccc}
\text{Land Unit} & \text{Year 1} & \cdots & \text{Year n} & \cdots & \text{Year 20} & \cdots & \text{Year 20+n} \\
\boldsymbol{LU_1} & SOC_j - S(j,i) & \cdots & SOC_{J_{1,n-1}} - S(j,i) & \cdots & SOC_{J_{1,19}} - S(j,i) & &
\end{array}\right|$$

Official Use

$$\left|\begin{array}{cccccccc}
\vdots & & \vdots & \vdots & \vdots & \vdots & \vdots & \\
\boldsymbol{LU_n} & & & SOC_j - S(j,i) & \cdots & SOC_{J_{n,19-n}} - S(j,i) & \cdots & SOC_{J_{n,19+n}} - S(j,i) \\
\text{Stable Forest} & SOC_J & \cdots & SOC_J & \cdots & SOC_J & \cdots & SOC_J
\end{array}\right|$$

$$=$$

__Multiplying the two tables leads to the following results for the application in Equation 2.25 to the Reference Level__

$$\left|\begin{array}{cccccccc}
\text{Land Unit} & \text{Year 1} & \cdots & \text{Year n} & \cdots & \text{Year 20} & \cdots & \text{Year 20+n} \\
\boldsymbol{LU_1} & \mathrm{TS(j,i)}_{1,1} & \cdots & \mathrm{TS(j,i)}_{1,n} & \cdots & \mathrm{TS(j,i)}_{1,20} & \cdots & \\
\vdots & & & \vdots & \vdots & \vdots & \vdots & \\
\boldsymbol{LU_n} & & & \mathrm{TS(j,i)}_{n,n} & \cdots & \mathrm{TS(j,i)}_{n,20-n} & \cdots & \mathrm{TS(j,i)}_{n,20+n} \\
\text{Stable Forest} & \mathrm{TS(j)}_1 + \sum_{LU=1}^{n} TS(j,i)_1 & \cdots & \mathrm{TS(j)}_n + \sum_{LU=1}^{n} TS(j,i)_n & \cdots & \mathrm{TS(j)}_{20} + \sum_{LU=1}^{n} TS(j,i)_{20} & \cdots & \mathrm{TS(j)}_{20+n} + \sum_{LU=1}^{n} TS(j,i)_{20+n}
\end{array}\right|$$

Applying the IPCC approach, annual changes in the Soil Organic Carbon pool are calculated as total SOC for year 0 – total SOC for the previous year (0-1), using the Equation 5.

$$AC_{Mineral_t} = \left[\mathrm{TS(j)}_{n-1} + \sum_{LU=1}^{n} TS(j,i)_{n-1}\right] - \left[\mathrm{TS(j)}_n + \sum_{LU=1}^{n} TS(j,i)_n\right]$$

Equation 13

Where:

$\mathrm{A(j,i)}_{\mathrm{LU}}$ Area converted/transited from forest type j to non-forest type i of the Land Unit LU, in hectares per year.

$$\mathrm{A(j,i)}_{\mathrm{LU}} = \frac{\mathrm{P(j,i)}_{\mathrm{LU}}}{\mathrm{N}} \times \mathrm{AA}$$

Equation 5.1

$\mathrm{P(j,i)}_{\mathrm{LU}}$: Number of points converted from forest type j to non-forest type i in the Land Unit LU, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program Accounting Area (in hectares)

In this case, four forest land conversions are possible resulted from the combinations of the following forest and non-forest types:

Forest type	Non-forest types
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest.	One type of non-forest land is considered: • Non-forest land use

• Pine forest, and • Mangrove forest.	

Technical corrections applied to this parameter: The deforestation activity data was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions.

$S(j,i)$ Soil Organic Carbon Linear decreasing rate for transition j to i, in tons of C per ha per year.

$$S(j,i) = \frac{SOC_j - SOC_i}{D}$$ **Equation 5.2**

SOC_j Soil Organic Carbon of forest type j before conversion/transition, in tons of C per ha.

SOC_i Soil Organic Carbon of non-forest type i after conversion, in tons of C per ha.

Technical corrections applied to these parameters: The SOC values (before and after forest transition) were technically corrected to replace the original estimates sourced from National Forest Inventory. The soil organic carbon pool estimates in the NFI of the Dominican Republic presented errors and methodological limitations.

NFI soil samples were collected from the upper 15 cm of soil. However, the soil organic carbon stock was calculated from the upper 30 cm. Generally, the SOC decreases with sampling depth. Also, the gravel content was ignored during the SOC pool calculation. Rock fragments do not have organic carbon, and the coarse stone percentage is sometimes very high. Calculate SOC at 30 cm using soil values taken at 15cm, and without considering the coarse volumetric ratio, overestimate the pool of SOC and, consequently, the deforestation emission factor.

To avoid the overestimation of SOC, two hundred sixty paired plots were established (130 in forest lands and 130 in non-forest use) to measure Soil Organic Carbon before and after deforestation, comparing the SOC between pairs by type of vegetation.

D Time in years where SOC_j decrease linearly to a new equilibrium SOC_i. A period of twenty years is assumed for all types of forest to non-forest conversions.

$TS(j,i)$ Soil organic carbon remaining in the Land Unit in the transition j to I, in tons of C.

$$TS(j,i)_{n,n} = \mathrm{A(j,i)_{n,n}} \times \left(SOC_j - S(j,i)\right)$$ **Equation 5.3**

$TS(j)$ Soil organic carbon remaining in the Stable Forest type j, in tons of C.

$$TS(j)_{n,n} = \mathrm{A(j)_{n,n}} \times SOC_j$$ **Equation 5.4**

$\mathrm{A(j)}$ Area of Stable Forest type j, in hectares.

$$\mathrm{A(j)} = \frac{\mathrm{P(j)}}{\mathrm{N}} \times \mathrm{AA}$$ **Equation 5.5**

$\mathrm{P(j)}$: Number of points from forest type j, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Accounting Area (in hectares)

Technical corrections applied to this parameter: The Stable Forest area estimate was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions.

Carbon removals associated with natural and artificial regeneration, including plantations (Enhancement of forest carbon stocks):

Equation 6 is used to calculate annual carbon removals associated with regeneration. The net annual carbon removals are computed using equations 2.15 and 2.16 from the 2006 IPCC Guidelines, Volume 4, Chapter 2 (Equations 3 and 4). These equations are simplified by assuming that the conversion from non-forest to forest occurs during a period from average carbon stocks in non-forest to average carbon stocks in secondary forests and is equal to the net annual increase in total biomass (ΔC_G-ΔC_L). The removal estimate considers changes in carbon stocks in above- and below-ground biomass, dead organic matter, and litter. SOC in mineral soils is omitted.

The dataset used to estimate the annual change in carbon stocks in biomass on land converted to forest includes carbon densities of secondary forests. Stands' age ranges from 4 to 42 years. Considering the range of age of the secondary forest sampling plots, for all forest types, a period of 44 years is assumed for the stand to grow from the carbon stock levels of non-forest to the average biomass and litter pools of the secondary forest.

Land units have been created to track the area converted to forest land in a specific year and remains as forest during the reference and crediting period, considering deforestation in the secondary forest cohort. The Removals are calculated by multiplying the area of land planted with the tons of C per hectare.

$$\left|\begin{array}{cccccccc}
\text{Land Unit} & \text{Year 1} & \cdots & \text{Year n} & \cdots & \text{Year 44} & \cdots & \text{Year 44+n} \\
\boldsymbol{LU_1} & R(\mathrm{j,i})_{1,1} \times \Delta C_{RB_i} & \cdots & \mathrm{R(j,i)_{1,n}} \times \Delta C_{RB_i} & \cdots & \mathrm{R(j,i)_{1,44}} \times \Delta C_{RB_i} & & \\
\vdots & & & \vdots & \vdots & \vdots & \vdots & \\
\boldsymbol{LU_n} & & & \mathrm{A(j,i)_{n,n}} \times \Delta C_{RB_i} & \cdots & \mathrm{A(j,i)_{n,44-n}} \times \Delta C_{RB_i} & \cdots & \mathrm{A(j,i)_{n,44+n}} \times \Delta C_{RB_i} \\
\text{Stable Forest} & \sum_{LU=1}^{n} R(j,i)_n \times \Delta C_{RB_i} & \cdots & \sum_{LU=1}^{n} R(j,i)_n \times \Delta C_{RB_i} & \cdots & \sum_{LU=1}^{n} R(j,i)_{44} \times \Delta C_{RB_i} & \cdots & \sum_{LU=1}^{n} R(j,i)_{20+n} \times \Delta C_{RB_i}
\end{array}\right|$$

$$\Delta C_{RB_t} = \sum_{LU=1}^{n} R(j,i)_n \times \Delta C_{RB_i}$$ **Equation 6**

Where:

$R(\mathrm{j,i})_{\mathrm{LU}}$ Area converted from non-forest type *j* to forest type *i* of the Land Unit LU, in hectares per year.

$$\mathrm{R(j,i)_{LU}} = \frac{\mathrm{P(j,i)_{LU}}}{\mathrm{N}} \times \mathrm{AA}$$ **Equation 6.1**

$\mathrm{P(j,i)_{LU}}$: Number of points converted from non-forest type *j* to forest type *i* in the Land Unit LU, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program Accounting Area (in hectares)

In this case, four forest land conversions are possible resulted from the combinations of the following forest and non-forest types:

Non-forest types *j*	Forest type *i*
One type of non-forest land is considered: • Grasslands	Four forest types: • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest.

Technical corrections applied to this parameter: The area estimate of other land converted to the forest was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions.

$$\Delta C_{RB_i} = \frac{B_{non-forest} - B_{forest_i}}{m}$$ **Equation 14.2**

ΔC_{RB_i}	Annual change in carbon stocks in biomass on land converted to forest *i*, in tC per ha per year;
$B_{non-forest}$	Soil Organic Carbon of forest type j before conversion/transition, in tons of C per ha;
B_{forest_i}	Soil Organic Carbon of non-forest type i after conversion, in tons of C per ha;
m	Time elapsed to reach B_{forest_i}, in years.

Technical corrections applied to these parameters: The ΔC_{RB_i}values were technically corrected to replace the original estimates sourced scientific literature. Now the net annual carbon removals are computed using equations 2.15 and 2.16 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. These equations are simplified by assuming that the conversion from non-forest to forest occurs during a period from average carbon stocks in non-forest to average carbon stocks in secondary forests and is equal to the net annual increase in total biomass (ΔC_G-ΔC_L).

Based on FC maps, a forest cover change analysis was prepared, and secondary forest cohorts were mapped into two categories: i. Secondary Forest cohort 4-22 years, and ii. Secondary Forest cohort 22-44 years. All forest inventory plots in forest and tree-shaded crops were classified into these two categories. By forest type, carbon content was directly derived from the biomass sampling plots database (average and 90%CI). In secondary forest types with less than ten sampling plots, additional forest plots were inventoried. A series of 32 secondary sampling units were inventoried in 2021, and age was determined from different sources: interviews and satellite information and secondary data.

Change in total biomass carbon stocks in forest lands that remains as forest (Forest Degradation):

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document, for applying IPCC Guidelines and guidance in the context of REDD+, the equation 2.16 of the 2006 IPCC GL can be simplified by assuming that the change in total biomass carbon stocks (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$). Thus, the change of biomass carbon stocks in forest lands that remains as forest during the Reference Period was calculated with the **Equation 4**:

$$\Delta C_{DegB_{RP}} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) \times Deg(j,i)_{RP}$$ **Equation 15.2**

Where:

$\Delta C_{DegB_{RP}}$ Change in total biomass carbon stocks in forest lands that remains as forest during the reference period, in tC.

$\mathrm{Deg(j,i)_{RP}}$ Area converted from forest with canopy cover j to forest with canopy cover i during the Reference Period, in hectares.

$$\mathrm{Deg(j,i)_{RP}} = \frac{\mathrm{P(j,i)_{RP}}}{\mathrm{N}} \times \mathrm{AA} \qquad \textbf{Equation 4.3}$$

$\mathrm{P(j,i)_{RP}}$: Number of points converted from forest with canopy cover *j* to forest with canopy cover *i* during the Reference Period, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program accounting area (in hectares)

In this case, twenty-eight canopy cover transitions forest are possible resulted from the combinations of the following forest and canopy cover categories:

Forest type	Canopy cover category
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest. • Agricultural tree-shaded crops	Three canopy cover categories: • Intact forest (>85%). • Degraded forest (60-85%), and • Very degraded forest (30-60%) • Agricultural tree-shaded crops

Technical corrections applied this parameter: The degradation/enhancement of canopy cover activity data was updated with a new visual assessment on high-res imagery using a 2.5 x 2.5 km grid instead of the original 5 x 5 km grid, thus reducing the standard error in uncommon transitions. Also, considering that FC maps provide a more robust determination of Canopy Cover than high-resolution imagery interpretation, forest cover and its probability were extracted from FC maps for each sampling point located in a permanent forest in the systematic grid. This information made it possible to assign each point the canopy cover class 30-60%, 60-85%, and >85% for the later analysis of canopy cover change.

$\mathrm{B_{Before,j}}$ Total biomass of forest type *j* before transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type.

$\mathrm{B_{After,i}}$ Total biomass of forest type *i* after transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{after}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{after}), litter (L_{after}) and death wood (DW_{after}) and it is defined for each forest type.

Technical corrections applied to this parameter: The original calculation of emissions and removals resulting from canopy cover loss and gain was based on AGB-canopy cover linear regression models for broadleaf, dry, and pine forests. These models were applied to estimate the loss and gain of biomass during the reference period. Total biomass was recalculated for each canopy cover category (>85%, 60-85%, and 30-60%) for each forest type (omitting secondary forests). All forest inventory plots in forest lands were classified into four categories based on terraPulse data. By forest type and degradation class, carbon content was directly derived from the biomass sampling plots database (average and 90%CI). Description of this parameter may be found in Annex 4 – Section XX.

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

Activity data

Parameters:	$A(j,i)_{RP}$; $A(j,i)_{LU}$, A(j) and $R(\mathrm{j,i})_{\mathrm{LU}}$
Description:	$A(j,i)_{RP}$: Area converted from forest type j to non-forest type i during the Reference Period, in hectares. **Equation 4.1**. $A(j,i)_{LU}$: Area converted from forest type j to non-forest type i of the Land Unit LU, in hectares. **Equation 5.1**. A(j): Area of Stable Forest type j, in hectares **Equation 5.5** $R(\mathrm{j,i})_{\mathrm{LU}}$: Area converted from non-forest type *j* to forest type *i* of the Land Unit LU, in hectares. **Equation 6.1**.
Data units:	Hectares
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Spatial level of data**: National **Sources of data**: Sampling-based estimates and associated uncertainties were used to calculate the activity data. Annual activity data for deforestation and forest regeneration were derived from the systematic sampling procedure (7,697 Permanent Sampling Units). **Methods:** Activity data estimate was made by applying the good practices and procedures identified by Olofsson et al. (2014) [105], GFOI (2016)[106] and GFOI (2021)[107]. The Dominican Republic MRV team prepared a Standard Operation Procedure for the sample-based REDD+ activity data estimation[108]. Although good practice recommends a stratified sampling to ensure a minimum number of plots in small strata, a systematic 2.5 x 2.5 km grid was used to generate activity data. Stratified sampling was not implemented due to the low accuracy of the non-permanent categories of the land-use change map for the period 2006-2015 (see Table A4.1) and because the use of independent surveys and temporary sample units does not enable the consistent and explicit tracking of land use spatially and temporally. The density of the systematic grid was estimated from the analysis of 474 systematic sampling points collected by Ovalles (2018)[109]. According to this analysis, with a sample size of 1942, it is possible to achieve a standard error of global precision of S(ô) = 0.01. However, DIARENA established a 2.5 x 2.5 km grid with 7,697 sampling points to reduce the standard error in uncommon transitions.

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[105] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

[106] GFOI. (2016). Integración de las observaciones por teledetección y terrestres para estimar las emisiones y absorciones de gases de efecto invernadero en los bosques. Métodos y orientación de la Iniciativa Mundial de Observación de los Bosques (Edición 2.). Roma: Organización de las Naciones Unidas para la Alimentación y la Agriculta.

[107] GFOI. (2021). Issues and good practices in sample-based area estimation.

[108] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

[109] Ovalles, P. (2018). Elaboración de mapa de Uso y Cobertura del Suelo 2015. Análisis de Cambios y Mapa de Deforestación en la República Dominicana. Informe Final. Santo Domingo, República Dominicana.

Permanent Sample Units (PSU) of one hectare (100 x 100 meters) with a single evaluation point corresponding to the plot centroid was defined for the first phase[110]. PSUs were visually interpreted through time to ensure the ***temporal tracking of land use***. Land-use assessments were made for 2000, 2005, 2015, and 2018. The land-use class was interpreted with context and recorded for the individual pixel or point for t1 and t2. Using the land-use type at t1 and t2, the change class was determined for the pixel or point. Using single point Land-use change class information, areas of change were calculated for the population. Interpreters also collected the ***transition year*** in the PSUs with a land-use change registered between assessments.

The Collect Earth Desktop (CED)[111] tool was used to perform the Multitemporal Visual Interpretation (MVI). Using Collect Earth Online[112] (CEO) was discarded. Unlike the CEO, CED provides access to high-resolution images from Google Earth, Bing Maps, and Planet, including medium (Sentinel) and low-resolution (Landsat) imagery from 2000 to 2018.

Value applied:

More than 400 activity data were estimated for the calculation of annual net emissions from deforestation and forest regeneration: Deforestation (96 land conversion types), SOC change transitions (160 Land Units), Permanent Forest types (5 types), and Forest regeneration (160 transitions). A summary of activity data values by forest type is shown in the below tables. All values can be consulted in the Activity Data tool ((TF-OT, TF-TF, OT-TF, and SOC TF-OT sheets [113].

Table 8-2: Deforested and Permanent Forest areas for the Reference Period 2006-2015.

Forest type	Deforested Area (ha) 2006-2015 (TF-OT) Total Biomass emissions	Permanent forest (ha) 2006-2015 (TF-TF)
Wet Broadleaf Forest	62,689	517,027
Dry Broadleaf Forest	31,655	358,753
Pine Forest	6,827	238,962
Agricultural Tree Crops	9,310	163,860
Mangroves	0	17,379

Table 8-3: Deforested Area (ha) (TF-OT) for SOC inherited emissions calculation*.

Forest type	1984-2000**	2001-2005	2006-2015
Wet Broadleaf Forest	269,375	16,758	49,654
Dry Broadleaf Forest	44,068	8,069	21,724
Pine Forest	0	4,345	3,724
Agricultural Tree Crops	0	621	8,069
Mangroves	0	0	0

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[110] A 7x7 points SU was planned to be used for a second phase to assess canopy cover only at permanent forest areas identified in the first phase. However, the country did not complete this analysis because canopy cover maps were used as the source of data to estimate the carbon fluxes in the permanent forest lands.

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

[112] https://collect.earth/

[113] DatosDeActivitidad-PR.xlsx tool can be accessed at the following link: https://app.box.com/s/wi8ayypl9bkpy8mpss43w4jgz2bp61yy

**Activity data used to estimate SOC emissions does not include secondary forest loss area*

*** Deforested Area between 1984-2000 was obtained using the annual canopy cover maps 1984-2021 as reference data to define the year of the forest loss.*

Table 8-4: Forest Gain 2006-2015 (ha) (OT-TF) for inherited removals calculation.

Forest type	1984-2000*	2001-2005	2006-2015
Wet Broadleaf Forest	209,790	230,273	338,892
Dry Broadleaf Forest	103,654	122,895	153,929
Pine Forest	60,206	64,551	85,033
Agricultural Tree Crops	76,344	78,826	98,688
Mangroves	1,862	1,862	2,483

** Forest Gain Area between 1984-and 2000 was obtained using the annual canopy cover maps 1984-2021 as reference data to define the year of change to new forest areas.*

QA/QC procedures applied

The Dominican Republic MRV team prepared a Standard Operation Procedure (SOP) for the sample-based REDD+ activity data estimation[114]. This SOP includes a quality control and quality assurance (QA/QC) procedure and a visual interpretation decision tree for high-resolution and low-resolution imagery to ensure the analysts used the best imagery dataset during the photo-interpretation of the land-use class in the sampling point.

Analysts received training to calibrate the observations and make clear the procedures to collect accurate data. After completing the training, the analysts interpreted a sample of 50 points. An analysis of differences between analysts was made, and no significant differences (95% significance) were found between them. Thus, the consistency between analysts was ensured.

During the MVI process, a specialist with extensive experience supervised the work of the analysts. The supervisor reviewed monthly deliveries of photo-interpreted points. This review focused on identifying and correcting errors and checking transition consistency and the years of change registered.

Finally, according to QA/QC procedures, the minimum level of consistency between the analysts and the supervisor should be 90% on land-use interpretation. Once all sampling points were assessed, the supervisor selected 100 plots per assessment (year) for consistency verification. The land use definition for the whole period (2000-2118) had 95% consistency between analysts and the supervisor (see table 3-7).

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[114] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

Table 8-5: General consistency between analysts and the supervisor on land-use interpretation.

Assessment	Points interpreted consistently	n	%
2000	82	97	85%
2006	82	95	86%
2015	84	91	92%
2018	90	96	94%
Total	360	379	95%

Uncertainty associated with this parameter:

Table 8-6: Estimation error of Deforested and Permanent Forest areas for the Reference Period 2006-2015.

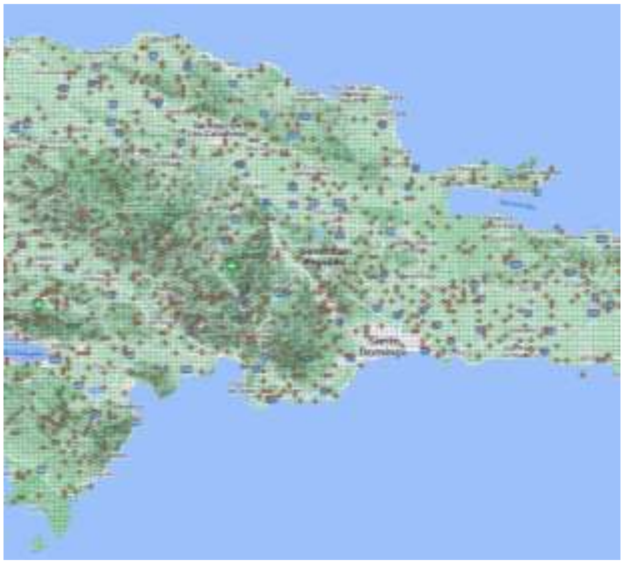
Forest type	Estimation error of Deforested Areas 2006-2015 (TF-OT) Total Biomass emissions	Estimation error of Permanent Forest areas 2006-2015 (TF-TF)
Wet Broadleaf Forest	20%	6%
Dry Broadleaf Forest	28%	8%
Pine Forest	66%	10%
Agricultural Tree Crops	55%	12%
Mangroves	NA	39%

Table 8-7: Estimation error of Deforested Area (ha) (TF-OT) for SOC inherited emissions calculation.

Forest type	1984-2000	2001-2005	2006-2015
Wet Broadleaf Forest	9%	39%	22%
Dry Broadleaf Forest	24%	60%	34%
Pine Forest	NA	89%	100%
Agricultural Tree Crops	NA	1271%	60%
Mangroves	NA	NA	NA

Table 8-8: Estimation error of Forest Gain Area (ha) (OT-TF) for inherited removals calculation.

Forest type	1984-2000*	2001-2005	2006-2015
Wet Broadleaf Forest	11%	10%	8%
Dry Broadleaf Forest	16%	14%	12%
Pine Forest	21%	19%	17%
Agricultural Tree Crops	18%	17%	16%
Mangroves	184%	184%	139%

Any comment:	Activity data estimate for reference and monitoring periods is based on land-use tracking from 2000 to 2024. The activity data includes two data sets: i. Reference Level consists of three subperiods 2000-2005, 2005-2015, and 2015-2018; ii. Monitoring Periods consist of tree subperiods, 2018-2021, 2021-2023 and 2023-2024. The 2018 measurement is common to both activity data sets (Reference Level and Monitoring Periods), 2018 was reassessed in the monitoring period. Once the visual assessment was completed, the 2018 land-use of 985 points (13% of the 7,697 sampling points in the systematic grid), were not consistent between the two data sets. The availability of new high-resolution images in the 2022 measurement improved the interpretation of land use in the Monitoring Period dataset. The updated 2018 measurement affected the transitions and land-use assessments made in the Reference Period dataset. Therefore, it was necessary to revise the land-use interpretations and the transitions of the 985 inconsistent points in the two data sets (2000-2018 and 2018-2024).  Figure 8-1: Spatial distribution of 985 inconsistent points.

Parameter:	$\mathrm{Deg(j,i)_{RP}}$:
Description:	$\mathrm{Deg(j,i)_{RP}}$: Area converted from forest with canopy cover j to forest with canopy cover i during the Reference Period, in hectares per year. **Equation 4.3.**
Data unit:	Hectares
Source of data or description of the method for developing the data including the	**Spatial level of data**: National **Sources of data**: Sampling-based estimates and associated uncertainties were used to calculate the activity data. Forest cover annual maps were used as reference information to determine the canopy cover categories for each sampling point.

spatial level of the data (local, regional, national, international):	**Methods:** Annual activity data for degradation and carbon enhancement in permanent forest were derived from the systematic sampling procedure (7,697 Permanent Sampling Units) and Forest Cover (FC) annual maps. Activity data estimate was made by applying the good practices and procedures identified by Olofsson et al. (2014) [115], GFOI (2016)[116] and GFOI (2021)[117]. The Dominican Republic MRV team prepared a Standard Operation Procedure for the sample-based REDD+ activity data estimation[118]. FC maps provide a more robust determination of Canopy Cover than high-resolution imagery interpretation. Therefore, forest cover and its probability were extracted from FC maps for each sampling point located in a permanent forest in the systematic grid to assign the canopy cover class 30-60%, 60-85%, and >85% for the later analysis of canopy cover change. One pixel was assigned to a canopy cover class if the probability of having a canopy cover above the threshold C was higher than 90%. Tree-canopy cover was estimated through an automatic learning algorithm based on a model f of remotely sensed variables X in any location I, $\widehat{C_\iota} = f\left(X;\hat{\beta}\right) + \varepsilon$. $\widehat{C_\iota}$ is the percentage of a pixel (i)'s area covered by trees; β is a set of empirically estimated parameters; ε is residual error or uncertainty; and X is a set of measurements of surface reflectance, derived indices (NDVI, NDWI, and MNDWI) and metadata describing acquisition and sensor characteristics (Sexton et al.2013)[119]. This algorithm was applied to the stack of Landsat images available for each year, to prepare the Dominican Republic annual canopy cover wall-to-wall raster maps from 1984 to 2021, with 30*30 m resolution; each pixel has a canopy cover value and the probability estimate. Further information on the preparation methods of canopy cover maps is detailed in Consultancy Report[120].

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[115] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

[116] GFOI. (2016). Integración de las observaciones por teledetección y terrestres para estimar las emisiones y absorciones de gases de efecto invernadero en los bosques. Métodos y orientación de la Iniciativa Mundial de Observación de los Bosques (Edición 2.). Roma: Organización de las Naciones Unidas para la Alimentación y la Agriculta.

[117] GFOI. (2021). Issues and good practices in sample-based area estimation.

[118] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

[119] Sexton, JO, X-P Song, M Feng, P Noojipady, A Anand, C Huang, D-H Kim, KM Collins, S Channan, C DiMiceli & JR Townshend. 2013a. Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS continuous fields and lidar-based estimates of error. International Journal of Digital Earth 6: 427-448

[120] terraPulse, 2018. Estimation of Activity Data on Deforestation, Forest Degradation and Enhancement of Forest Carbon Stocks of Dominican Republic using Annual Time Series Analysis of Landsat data. Technical Document. 12 p. https://app.box.com/s/0i7wl8wss4l40mjl3299gfwpo4i7djoz

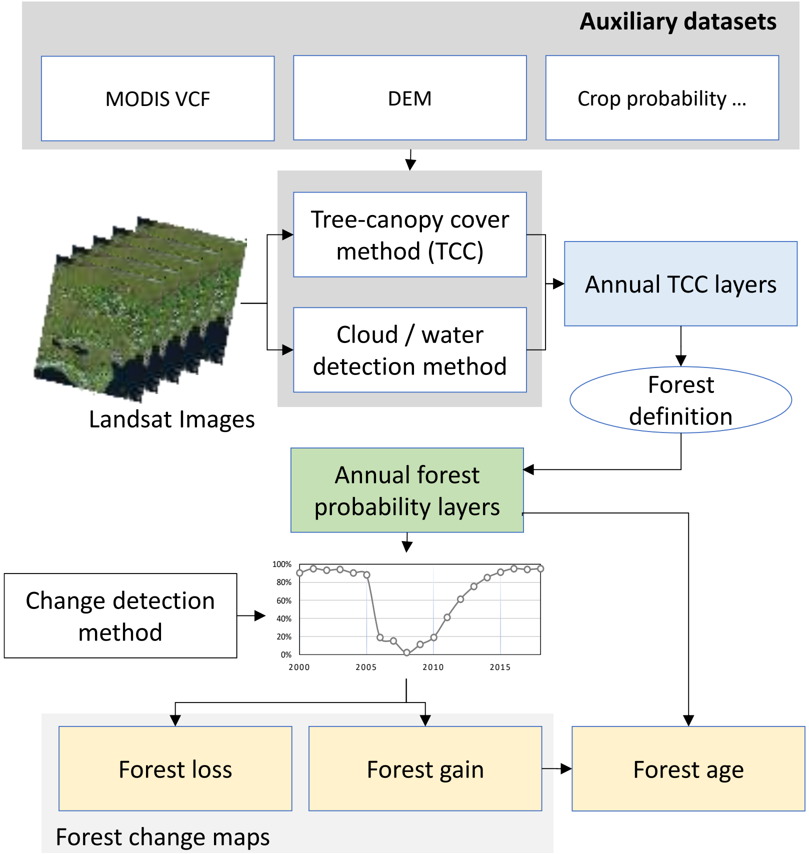

Figure 8-2. Estimation of percent-tree cover as a standard normal distribution of cover (mean) and uncertainty (standard deviation) in each pixel (Sexton et al. 2015)[121].

Value applied:

More than 48 activity data were estimated for the annual emission of degradation and carbon enhancement in permanent forest. A summary of activity data values by forest type is shown in the following table. All values can be consulted in the Activity Data tool (TF-TF sheets) [122].

Table 8-9: Canopy cover transition areas in permanent forest lands - 2006-2025

Canopy cover transition in permanent forest lands		Area 2006-2015 (ha)
Wet Broadleaf Forest	Enhancement	131,584
	Degradation	42,206
Dry Broadleaf Forest	Enhancement	22,965

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[121] Sexton, JO, P Noojipady, A Anand, X-P Song, C Huang, SM McMahon, M Feng, S Channan & JR Townshend. 2015. A model for the propagation of uncertainty from continuous estimates of tree cover to categorical forest cover and change. Remote Sensing of Environment 156: 418-425

[122] DatosDeActivitidad-PR.xlsx tool can be accessed at the following link: https://app.box.com/s/wi8ayypl9bkpy8mpss43w4jgz2bp61yy

	Degradation	27,931
Pine Forest	Enhancement	37,862
	Degradation	22,345
Agricultural Tree Crops	Native forest	621
Native forest	Agricultural Tree Crops	1,862
Mangroves	Enhancement	6,207
	Degradation	1,241

QA/QC procedures applied

The same QA/QC procedures for deforestation and regeneration were applied to the estimate of degradation activity data. In this case, QA/QC procedures were focused on the interpretation of permanent forest areas.

Uncertainty associated with this parameter:

The canopy cover change category determination uncertainty for each sampling plot in the systematic grid was calculated at **6%** for degradation and canopy cover recovery classes[123]. This uncertainty was calculated by the bootstrap method, with 1000 simulations based on the bias estimate. The bias of the canopy cover in Forest Cover maps is 4.34%, with a standard deviation of 61.691. Likewise, the sampling error of estimating the areas of the canopy cover class change was also calculated (table below). Both uncertainties are included in the propagation error of the reference emission level.

Table 8-10: Estimation error of canopy cover transition areas in permanent forest lands - 2006-2015

Canopy cover transition in permanent forest lands		Area 2006-2015 (ha)
Wet Broadleaf Forest	Enhancement	13%
	Degradation	24%
Dry Broadleaf Forest	Enhancement	33%
	Degradation	30%
Pine Forest	Enhancement	26%
	Degradation	34%
Agricultural Tree Crops	Native forest	1271%
Native forest	Agricultural Tree Crops	184%
Mangroves	Enhancement	70%
	Degradation	304%

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[123] The Excel tool used to estimate the canopy cover change category determination uncertainty by the bootstrap method can be accessed at the following link: https://app.box.com/s/ex2otzvkk4u32armla8rory8as9iu7tj

Any comment:	There are no comments.

Emission factors

Parameters:	$B_{Before,j}$; $B_{After,i}$; ΔC_{RB_i}
Description:	$B_{Before,j}$: Total biomass of forest type j before conversion, **Equation 4.** $B_{After,i}$: Total biomass of non-forest type i after conversion, **Equation 4.** ΔC_{RB_i}: Annual change in carbon stocks in biomass on land converted to forest *i*, **Equation 6.2.**
Data units:	$B_{Before,j}$; $B_{After,i}$ tons of C per ha ΔC_{RB_i} tons of C per ha per year
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Spatial level of data**: National **Sources of data**: Three sources of data were used to estimate total biomass in each of the land uses and the emission factors in the land-use change categories: a. The National Forest Inventory (**NFI**)[124], b Assessment of Biomass and Carbon Content in Non-Forest Cover in the Dominican Republic" (**ISNB**)[125], and c. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015 (**Technical Correction Inventory**) [126]. **Methods**: The inventories were compiled using the same methodology, sampling unit, and nested plots in order to determine carbon density for each component recognized as a sink. Each carbon pool is estimated using the database at the tree level, taking the area of the sampling units into account. Allometric models used to estimate the above-ground biomass of the components recorded in these three inventories are listed above. Due to there being no specific allometric equations for broadleaf forests in the Dominican Republic, above-ground biomass (AGB) calculations are carried out using the allometric equations of Chave et al. (2014)[127] in the three inventories. For pine trees, a local allometric equation is used. Allometric equations developed in Nicaragua and Costa Rica are used for coffee, cocoa, coconut, mango, avocado, and guava. The Cairns et al. (1997) [128] equation is used to quantify below-ground biomass roots. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47). With these three surveys a total of 573 plots[129] were collected, with estimations of the above-ground biomass (AGB), dead material (DM) and litter (L). Total biomass of forest types and non-forest types is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type.

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[124] Ministry of the Environment. 2015. Inventario nacional forestal de la República Dominicana: Measure and assess forests in order to understand their diversity, composition, volume and biomass. Field Manual. Forest Monitoring Unit. REDD7CCAD-GIZ. Regional Project 48 pages

[125] Ministry of the Environment. 2017. Assessment of the biomass and carbon content in non-forest systems in the Dominican Republic. Field Manual. Forestry Monitoring Unit REDD+ Preparation Project. 54 pages

[126]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

[127] Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, *20*(10), 3177–3190. https://doi.org/10.1111/gcb.12629

[128] Cairns, M. A., Brown, S., Helmer, E. H., Baumgardner, G. A., Cairns, M. A., Brown, S., … Baumgardner, G. A. (1997). Root Biomass Allocation in the World 's Upland Forests. Oecologia, 111(1), 1–11. http://doi.org/10.1007/s004420050201

[129] A copy of the database used to estimate carbon densities can be obtained by following this link: https://app.box.com/s/49fqku4tpmjo97bwm6px5zk988rlkutp

Table 8-11. Allometric models used to estimate the above-ground biomass of the components recorded in three biomass inventories (NFI, ISNB and Technical Correction Inventory).

Component	National Forestry Inventory (NFI) and Additional 32 biomass sampling plots	Evaluating the Biomass and Carbon Content in Non-Forest Cover (ISNB)
Trees (DBH ≥ 5 cm) all species	$AGB = (0.0673 * (GE * dap^2 * H_t)^{0.976})$ [130] Pantropical	
Trees of (2 > DBH < 5 cm) all species	$\ln(AGB) = -9.37673 + 2.30119\ln(dap) + 0.30297\ln(H_t)$[131] Petén, Guatemala	
Trees of P. occidentalis and P. caribaea. (>2 cm DBH)	$\ln(AGB) = 1.17 + 2.119 * \ln(dap)$[132] Dominican Republic	*Not applicable*
Coffee crop - Coffea arabica	$\ln(AGB) = -2.39287 + 0.95285 * LN(dap) + 1.2693 * LN(H_t)$[133] *(dap 0,3 - 7,5 cm; HT 0.31 - 3.40 m)*	$\log(AGB) = -1.181 + 1.991 * log(d15))$[134] Matagalpa, Nicaragua
Other crops: Cocoa - Theobroma cacao; Avocado - Persea americana; Guava - Psidium guajaba; Seville orange - Citrus aurantium, C. Sinensis; Mango - Mangifera indica.	*Not applicable*	$\log(AGB) = -1.11 + 2.64 * Log(dap)$[135] Talamanca, Costa Rica
Coconut - Cocos nucifera	*Not applicable*	$\log(AGB) = 6.8414 * dap^{2.086} + 2.7340 * dap^{2.1837} + 2.7402 * dap^{1.9408}$ *[136]* Costa Rica

TerraPulse developed annual forest cover maps based on the canopy cover and probability of change in forest cover from one year to another. This information offers long-term and consistent mapping and monitoring of forest cover. It allows the retrieval of historical reference scenarios from the satellite records and the detection of deforestation, degradation, and growth over time. Based on FC maps, a forest cover change analysis was prepared considering only pixels with> 90% probability of having a forest cover higher than 30%, 60% and 85%. Subsequently, forest degradation classes and secondary forest cohorts were mapped into four categories: i. Intact Forest (>85% crown cover), ii. Degraded forest (60-85% crown cover), iii. Highly degraded forest (30-60% crown cover) and iv. Secondary Forest.

All forest inventory plots in forest and tree-shaded crops were classified into these four categories based on terraPulse data. By forest type and degradation class, carbon content was directly derived from the biomass

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[130] Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. Global Change Biology, 20(10), 3177–3190. http://doi.org/10.1111/gcb.12629

[131] Arreaga, W. 2002. Almacenamiento de carbono en bosques con manejo forestal sostenible en la Reserva de Biosfera Maya, Petén, Guatemala. CATIE. Escuela de Postgrado. Tesis. 73p.

[132] Márquez (2000) citado por Brown (1996)

[133] Suarez (2002)

[134] Segura, M.; Kanninen, M.; Suárez, D. 2006. Allometric models for estimating aboveground biomass of shade trees and coffee bushes grown together. Agroforestry Systems 68(2): 143-150

[135] Andrade, H.J.; Segura, M.; Somarriba, E.; Villalobos, M. 2008. Valoración biofísica y financiera de la fijación de carbono por uso del suelo en fincas cacaoteras indígenas de Talamanca, Costa Rica.

[136] Ares, A., Boniche, J., Quesada, J., Yost, R., Molina, E. and Smyth, T. 2002. Estimacion De Biomasa Por Metodos Alometricos, Nutrimentos Y Carbono En Plantaciones De Palmito En Costa Rica. Agronomia Costarricense, (26): 19-30.

sampling plots database (average and 90%CI). The mean annual carbon change in secondary forest and tree-shaded crops (tC/ha/yr.) was estimated by dividing the carbon change between non-forest and secondary forest land use by the time elapsed to reach the maximum biomass of the secondary forest type determined from the forest cover change maps.

Value applied:

Table 8-12. Total forest biomass and non-forest land uses.

Land uses			Total Biomass (AGB+BGB+L+DW)		
			tC*ha^{-1}	n	Error
Permanent Forest	Pine	Intact forest	76.52 ± 7.4	25	10%
		Degraded forest	47.79 ± 10.3	14	22%
		Very degraded forest	44.19 ± 17.46	6	40%
	Dry Broadleaf Forest	Intact forest	43.43 ± 7.85	6	18%
		Degraded forest	42.63 ± 7.59	10	18%
		Very degraded forest	35.35 ± 14.24	21	40%
	Wet Broadleaf Forest	Intact forest	80.72 ± 11.75	75	15%
		Degraded forest	50.91 ± 8.89	67	17%
		Very degraded forest	39.38 ± 11.02	40	28%
	Agricultural tree crops		64.93 ± 10.32	58	16%
Secondary Forest	Pine	4-22yr	37.97 ± 23.15	9	61%
		22-44yr	57.49 ± 14.33	14	25%
	Dry Broadleaf Forest	4-22yr	27.62 ± 7	19	25%
		22-44yr	30.2 ± 4.81	33	16%
	Wet Broadleaf Forest	4-22yr	25.04 ± 4.24	39	17%
		22-44yr	47.59 ± 8.69	59	18%
Non-forest lands	Wet broadleaf shrubland		23.02 ± 10.67	17	46%
	Dry broadleaf shrubland		18.54 ± 8.28	25	45%
	Coconut		35.1 ± 10.97	12	31%
	Grassland		9.68 ± 4.25	24	44%
	Annual crops		14.85 ± 0.27		7%
	Human settlements		9.68 ± 4.25	24	44%
				573	

Table 8-13. Annual change in carbon stocks in biomass on land converted to forest

Type of Forest			Average of C Removal (AGB+BGB+L+DW)	
			tg C/ha/yr	Error
Secondary Forest	Pine	8-22yr	1.29	49%
		22-44yr	1.09	22%
	Dry Broadleaf Forest	8-22yr	0.82	22%
		22-44yr	0.47	16%
	Wet Broadleaf Forest	4-22yr	0.70	17%
		22-44yr	0.86	17%
	Agricultural Tree Crops	4-22yr	1.75	22%
		22-44yr	1.13	17%

QA/QC procedures applied

NFI: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[137] and QA/QC[138] procedures to reduce non-sampling errors. Since the beginning of the planning phase, courses on basic forest inventory techniques were given to 68 forestry technicians, half of them MARN officials and the other half personnel who work outside the Ministry. Then, three-day training workshops were held on INF-RD Field Manual, with the participation of 97 technicians selected. Subsequently, the crews responsible for the field survey were designated and received rigorous training in the Field Manual and the Quality Control Manual.

ISNB: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[139] to reduce non-sampling errors. The crew members for the fieldwork received training for implementing inventory methodology and QA/QC procedures. The inventory methodology was explained, and field practices were carried out, including measurements and sampling exercises. During this training, the crew leaders were confirmed according to their abilities and capacities.

Technical Correction Inventory: The quality control procedures during the implementation of the survey of the 32 additional plots have been made following the NFI´s Field Manual and QA/QC procedures prepared by the Ministry of Environment and Natural Resources. The Forest Monitoring Unit of the Ministry has formed a quality control brigade that applied the QA/QC procedures in these additional plots; Likewise, the MARN QA/QC team and fieldwork crews were trained. Both teams worked together for two days, putting the inventory QA/QC protocol into practice.

Uncertainty associated with this parameter:

The uncertainty associated with Total Forest biomass and non-forest land uses and Annual change in carbon stocks in biomass on land converted to forest are listed above in Tables 8-14 and 8-15. The Probability Distribution Function has been fitted for each Land-use carbon density class. Annual change in carbon stocks in biomass on land converted to the forest was calculated by combining uncertainties of land-use carbon densities before and after conversion, following IPCC approach 1 (addition and subtraction Eq 3.2).

Table 8-14: Uncertainty of total forest biomass and non-forest land uses

Land uses			Probability Distribution Function	Parameters
Permanent Forest	Pine	Intact forest	Weibull (2)	β 4.870; γ 83.450
		Degraded forest	Normal	μ 47.790; σ 17.845
		Very degraded forest	Fisher-Tippett (2)	β 11.870; μ 36.785
	Dry Broadleaf Forest	Intact forest	Logistic	μ 42.653; s 4.261
		Degraded forest	Normal	μ 42.634; σ 11.179
		Very degraded forest	Logistic	μ 30.905; s 13.279
	Wet Broadleaf Forest	Intact forest	Log-Normal	μ 4.203; σ 0.627
		Degraded forest	Fisher-Tippett (2)	β 24.799; μ 35.890
		Very degraded forest	Gamma (2)	k 1.317; β 30.894
	Agricultural tree crops		Fisher-Tippett (2)	β 29.744; μ 47.352
Secondary Forest	Pine	4-22yr	Fisher-Tippett (2)	β 19.378; μ 25.652
		22-44yr	Normal	μ 57.489; σ 25.757
	Dry Broadleaf Forest	4-22yr	Logistic	μ 26.467; s 8.076
		22-44yr	Fisher-Tippett (2)	β 10.671; μ 24.057

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[137] MARN-GIZ. 2014. Manual de Campo del Inventario Nacional Forestal de la República Dominicana. Unidad de Monitoreo Forestal. Programa REDD CCAD GIZ. Santo Domingo, R.D. 61p. https://app.box.com/s/e0jf1lb49wpbd2981f9iwvvo2gvbf0av

[138] MARN-GIZ. 2018. Protocolo para el control de calidad del Inventario Nacional Forestal de Republica Dominicana 2018. Unidad de Monitoreo Forestal y Unidad de Gestión del Proyecto de Preparación REDD+ de la República Dominicana. 9p. https://app.box.com/s/b9uoly8bpn5n4b8xivhtv2ob3z2gslub

[139] MARN, 2017. Manual de Campo: Evaluación del contenido de biomasa y carbono en sistemas de No Bosque en la Republica Dominicana. Unidad de Monitoreo Forestal. Proyecto de Preparación de REDD+. 54p. https://app.box.com/s/056lacpm9rwyw2uh7a0aqz4a5yye9ol4

	Wet Broadleaf Forest	4-22yr	Beta 4	α 1.796; β 3.103; c 0.957; d 66.777
		22-44yr	Log-Normal	μ 3.662; σ 0.630
Non-forest lands	Wet broadleaf shrubland		Exponential	λ 0.043
	Dry broadleaf shrubland		Gamma (2)	k 0.810; β 22.588
	Coconut		GEV	k 0.039; β 13.317; μ 23.660
	Grassland		Normal	μ 9.679; σ 10.287
	Annual crops		Normal	-
	Human settlements		Normal	-

Table 8-15: Uncertainty of Annual change in carbon stocks in biomass on land converted to forest

Type of Forest			Error
Secondary Forest	Pine	8-22yr	49%
		22-44yr	22%
	Dry Broadleaf Forest	8-22yr	22%
		22-44yr	16%
	Wet Broadleaf Forest	4-22yr	17%
		22-44yr	17%
	Agricultural Tree Crops	4-22yr	22%
		22-44yr	17%

Any comment:	Total biomass was recalculated for each canopy cover category (>85%, 60-85%, and 30-60%) into each permanent forest type and forest cohort. Also, the ΔC_{RB_i} values were calculated from biomass sampling plots to replace the original estimates sourced scientific literature.

Parameter:	$SOC_j, SOC_i\ ,\ S(j,i)$
Description:	SOC_j : Soil Organic Carbon of forest type j before conversion **Equation 5.2** SOC_i: Soil Organic Carbon of non-forest type i after conversion **Equation 5.2** $S(j,i)$: Soil Organic Carbon Linear decreasing rate for transition j to I **Equation 5.2**
Data unit:	SOC_j *and* SOC_i tons of C per ha $S(j,i)$ tons of C per ha per year
Source of data or description of the method for developing the data including the spatial level of the data (local, regional,	**Spatial level of data**: National **Sources of data**: SOC Estimate for each forest type and non-forest classes is based on the Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015 (**Technical Correction Inventory**) [140]. **Methods**: For the determination of the organic carbon balance of the soil after deforestation in the main types of soil, 260 plots were established in paired forest – non-forest plots. Sampling Plots were located ensuring at least five paired plots in each of the main transitions by soil type that add up to 80% of the area of change observed during the reference period (2006-15). The following samples were obtained in each of these plots: a. SOC sample 0-15 cm, b. SOC sample 15-30 cm, c. Unaltered sample Bulk Density 0-15 cm and d. Unaltered samples' Bulk

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[140]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

national, international):

Density of 15 - 30 cm. 520 samples (altered samples) were taken for laboratory analysis to determine the SOC. Likewise, 520 unaltered samples were analyzed to determine the Bulk Density and the volumetric fraction of coarse fragments[141].

Organic Carbon Concentration (OCC) was estimated with the Walkley-Black colorimetric method under the NVN 575 standard. Bulk density (BD) was determined by relating the soil sample's dry weight (105̊C) and the soil's volume.

The soil organic carbon stock was calculated as the product of organic carbon concentration (OCC), bulk density (BD), and the proportion of the volumetric fraction of coarse fragments (S). $\mathrm{SOC} = \mathrm{OCC} \times \mathrm{BD} \times \mathrm{D}(1 - \mathrm{S})$. OCC is in g x 100 g^{-1}, BD is in g x cm^{-3}, D is the thickness of the layer (30 cm) and S is in g x g^{-1}.

The Soil Organic Carbon Linear decreasing rate was calculated based on the estimate of SOC before and after conversion with Equation 2.25 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. Average SOC before and after conversion was estimated by forest types. The determination of the year of land-use conversion in the SOC sampling plot is based on an analysis of time series of high-resolution satellite images and Landsat imagery repositories available on the Google Earth platform. The average SOC after conversion includes grasslands, annual crops, and shrublands. Only samples with a SOC decrease after conversion was considered (64 samples)[142].

Value applied:

Table 8-16: Average SOC before and after conversion and SOC linear decreasing rate by forest types

Forest type	Soil Organic Carbon by forest type before conversion tC*ha^{-1}	Soil Organic Carbon by forest type after conversion tC*ha^{-1}	Soil Organic Carbon Linear decreasing rate tC*ha^{-1}*yr^{-1}	Number of sampling plots
Wet Broadleaf Forest	23.10	11.31	0.48	34
Dry Broadleaf Forest	34.37	22.45	0.67	15
Pine Forest	29.26	12.02	1.18	10
Agricultural Tree Crops	24.49	10.85	0.45	5

Values for Wet Broadleaf Forest were used for Mangrove transitions.

QA/QC procedures applied

The QA/QC procedure applied for the collection of SOC samples includes the following:

a. Field check that the sampling site corresponds to the type of transition to be sampled.

b. A field manual was prepared and implemented to collect 200 g soil samples at a depth of 0 to 15 cm and from 15 to 30 cm deep, as well as for the bulk density sample.

c. All samples were labeled and stored.

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[141] A copy of the original database of SOC before and after conversion can be accessed at the following link: https://app.box.com/s/a2ic2wqvrqxg36d3633poe8ziv1zdj8s

[142] A copy of the final database used to estimate average SOC before and after conversion can be accessed at the following link: https://app.box.com/s/07poveih5s7ifxjcryv7ciaqu20weq03

<table>
<tr><td></td><td>For further detail on QA/QC procedures, see section 3.2 of the consultancy report of the Technical Correction Inventory[143].</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>Estimation error of SOC linear decreasing was calculated combining uncertainties of average SOC before and after conversion, following IPCC approach 1 (addition and subtraction Eq 3.2).

Table 8-17: Estimation error of Average SOC before and after conversion and SOC linear decreasing rate by forest types

<table>
<tr><th>Forest type</th><th>Estimation error of Soil Organic Carbon by forest type before conversion</th><th>Estimation error of Soil Organic Carbon by forest type after conversion</th><th>Estimation error of Soil Organic Carbon Linear decreasing rate</th></tr>
<tr><td>Wet Broadleaf Forest</td><td>28%</td><td>30%</td><td>21%</td></tr>
<tr><td>Dry Broadleaf Forest</td><td>25%</td><td>28%</td><td>19%</td></tr>
<tr><td>Pine Forest</td><td>62%</td><td>34%</td><td>45%</td></tr>
<tr><td>Agricultural Tree Crops</td><td>73%</td><td>46%</td><td>52%</td></tr>
</table></td></tr>
<tr><td>Any comment:</td><td>There are no comments.</td></tr>
</table>

8.4 Estimated Reference Level

ER Program Reference level

Table A4-8-18: Technical corrected *ER Program Reference level*

Crediting Period year *t*	Average annual historical emissions from deforestation over the Reference Period (tCO$_{2-e}$/yr)	Average annual historical emissions from forest degradation over the Reference Period (tCO$_{2-e}$/yr)	Average annual historical removals by sinks over the Reference Period (tCO$_{2-e}$/yr)	Adjustment, if applicable (tCO$_{2-e}$/yr)	Reference level (tCO$_{2-e}$/yr)
2021	2,559,729	624,244	-3,278,409	NA	-94,437
2022	2,559,729	624,244	-3,278,409	NA	-94,437
2023	2,559,729	624,244	-3,278,409	NA	-94,437
2024	2,559,729	624,244	-3,278,409	NA	-94,437
Total	10,238,916	2,496,975	-13,113,638	NA	-377,748

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[143]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

Calculation of the average annual historical emissions over the Reference Period

The following table describes the set of tools developed by the Dominican Republic to estimate emissions and removal from deforestation, degradation, and forest regeneration. Also is provided a step-by-step description of the monitoring parameters used to establish the Reference Level and estimate Emissions and Emissions reductions during the Monitoring Period for the Carbon Pools and greenhouse gases selected in the ER-PD.

Table A4-8-19: Step-by-step description of the monitoring parameter and data integration tools to establish the Reference Level and estimate Emissions and Emissions reductions during the Monitoring Period for the Carbon Pools and greenhouse gases selected in the ER-PD.

Monitoring parameters and Data Integration tools	Step	Description of the measurement and monitoring approach
Monitoring parameters	Step 0	The input dataset used to estimate net emissions for the reference and monitoring period include the following databases: • Forest and Non-Forest SOC sampling plots database[144] • Visual interpretation of hi-res imagery[145] • Forest biomass sampling plots database (National Forest Inventory (NFI)[146] and Additional sampling plots[147]) • Non-Forest biomass sampling plots database[148] • Forest cover maps time series maps 1984-2021[149].
DatosDeActividad_PR.xlsx and DatosDeActividad_PM.xlsx	Step 1	The visual interpretation of hi-res imagery to determine land-use change used to estimate activity data for the Reference Period is included in the "***DatosReferencia***" sheet. This dataset is imported in CSV format from the database of interpreted points in Collect Earth Desktop.
	Step 2	Land-use change, degradation, deforestation, and regeneration analyses are included in the "***DatosReferencia***" sheet. These analyses are based on classification tables included in the "***TablasClasification***" sheet. Based on land-use change analyses, the calculation of deforestation, regeneration, and forest degradation is made in two activity data tools, one for Reference Period (PR) and another for the Monitoring Periods (PM). The activity data tool for PR includes the estimates for 1984-2000, 2001-2005, 2006-2015, and 2016-2018. PM tool includes 2016-2018, 2019-2021, 2022-2023, and 2024. Both tools are organized as follows: a. Deforestation: "***TF-OT***" sheet. b. Forest degradation: "***TF-TF***" sheet. c. Regeneration: "***OT-TF***" sheet.

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[144] The original database of soil organic carbon sampling plot data used to estimate the SOC linear decreasing rate estimate can be accessed at this link: https://app.box.com/s/tfu8h53kx7wtg7lyll5wff153h9q8itu

[145] The original database of visual interpretation of hi-res imagery to determine land-use change activity data during the reference and monitoring periods can be accessed at this link: https://app.box.com/s/tvfhjxaa5o9vdvkpak8cbivwjqcce5be

[146] The original NFI database used to estimate carbon densities can be accessed at this link: https://app.box.com/s/f6b71lxsdq7w2h1xwhh8ln3m0z6b95nl

[147] The original database of the 32 additional sampling plots used to estimate carbon densities can be accessed at this link: https://app.box.com/s/g6dq2i6yf5cdl2tqkye23m8srwkwn6su

[148] The original Non-Forest Biomass Inventory database used to estimate carbon densities can be accessed at this link: https://app.box.com/s/g6dq2i6yf5cdl2tqkye23m8srwkwn6su

[149] The time series of forest cover maps used to stratify the forest biomass sampling plot according to forest age and category of canopy cover can be accessed at this link: https://app.box.com/s/bkfw90jc4y58s8htpkkxw8s287n04q5m

Monitoring parameters and Data Integration tools	Step	Description of the measurement and monitoring approach
		d. SOC change associated with deforestation: "***SOC TF-OT***" sheet.
COS_EF.xlsx	Step 3	Soil Organic Carbon linear decreasing rate estimate is in the "**SOCEF**" sheet of the SOC emission factor tool.
CarbonDensities_Tool.xlsx	Step 4	The estimate of different emission factors for the secondary and permanent forest is made in the "***CarbonDensities***" sheet. The calculation is based on the datasets included in the "***Non-Forest Biomass Plots Data***" and "***Forest Biomass Plots Data***" sheets.
"Deforestacion y Degradacion" Sheet in CalculoReduccionEmisionesRD.xlsx	Step 5	The estimate of emissions from deforestation and degradation is made in the "Deforestacion y Degradacion" sheet. The calculation is based on "***TF-OT***" and "***TF-TF***" sheet estimates made in the activity data tools (DatosDeActividad_PR.xlsx and DatosDeActividad_PM.xlsx) and "**CabonDensities**" sheet in CarbonDensities_Tools.xlsx.
EmisionesHeredadasSOC Sheet in CalculoReduccionEmisionesRD.xlsx	Step 6	Estimate of change in the soil organic carbon pool in mineral soils associated with deforestation is based on the "***SOC TF-OT***" sheet calculation made in the activity data tools (DatosDeActividad_PR.xlsx and DatosDeActividad_PM.xlsx) and Soil Organic Carbon linear decreasing rate estimate in the "***SOCEF***" sheet of the SOC emission factor tool (COS_EF.xlsx).
"RemocionesHeredadas" Sheet in CalculoReduccionEmisionesRD.xlsx	Step 7	The estimate of carbon removal associated with natural and artificial regeneration is made in the "***Remociones Heredadas***" sheet. The calculation is based on the "***OT-TF***" sheet calculation made in the activity data tool (DatosDeActividad.xlsx) and Removal Factors in the "***CarbonDensities***" sheet of the Emission factor tool (FREL-RD_FOREST-CarbonDensities_Tool.xlsx).
CalculoReduccionEmisionesRD.xlsx	Step 8	The estimate of net emissions from deforestation, degradation and forest carbon stocks enhancement over the Reference and Monitoring Periods is made in "***Calculo RE***¨ based on "**Deforestacion y Degradadacion**", "***EmisionesHeredadas***" y "***RemocionesHeredadas***" sheets.
	Step 9	Emission reduction is also calculated in "***Calculo RE***" sheet. It is essential to clarify that a Pro-rata factor was applied to estimate the volume of ERs for the Reporting Period. The pro-rata factor corresponds to the fraction of the year 2021 between March 1st and December 31st .
EstimacionIncertidumbre.xlsx	Step 10	A results summary of the uncertainty estimates, and sensitivity analysis is in the ¨***Calculo RE***¨ sheet of EstimacionIncertidumbre.xlsx. This tool is based on the CalculoReduccionEmisiones.xlsx tool. This excel file was modified to calculate 10,000 iterations for the Emission Reduction estimate. The dataset with iterations for the different REDD+ activities considered in Emission calculation is included in the "***Iteraciones***" sheet. Emission Reduction Uncertainty consider the pro-rata factor application.

Reference Level ($\mathrm{RL_t}$)

Calculation of the average annual historical emissions over the Reference Period ($\mathrm{RL_t}$) is estimated as the net change in total biomass carbon stocks and organic carbon pool in mineral soils during the reference period.

$$\mathrm{RL}_t = \frac{\Delta C_{B_{RP}} + \Delta \mathrm{C}_{\mathrm{DegB}_{RP}} + \sum_{\mathrm{t}}^{\mathrm{RP}} \Delta \mathrm{C}_{\mathrm{RB}_{\mathrm{t}}} + \sum_{\mathrm{t}}^{\mathrm{RP}} \Delta \mathrm{C}_{Mineral_{\mathrm{t}}}}{RP}$$

Equation 16

Where:

$\Delta \mathrm{C}_{\mathrm{B}_{\mathrm{RP}}}$ = Change in total biomass carbon stocks in forest lands converted to other land-use category during the Reference period, in tC;

$\Delta \mathrm{C}_{\mathrm{DegB}_{RP}}$ = Change in total biomass carbon stocks in forest lands that remains as forest during the reference period, in tC;

$\Delta \mathrm{C}_{\mathrm{Mineral}_{\mathrm{t}}}$ = Annual change in the soil organic carbon pool in mineral soils associated with deforestation; tC*year^{-1};

$\Delta \mathrm{C}_{\mathrm{RB}_{\mathrm{t}}}$ = Annual change in total biomass carbon stocks in non-forest lands converted to forest lands categories at year t; tC*year^{-1};

RP = Reference period; years.

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

Not applicable.

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

In accordance with the Dominican Republic Third National Communication for the UNFCCC, in the AFOLU sector the greenhouse gas emissions resulting from the following categories are considered: domestic livestock: enteric fermentation and manure management; rice cultivation: flooded rice fields; required burning of savannah; field burning of agricultural residues; agricultural land; forest land; and biomass burning on forest land.

Forest land includes all land with mature vegetation with the thresholds used for the definition forest land. The NGGI considers emissions and absorptions resulting from changes in biomass, dead organic material and in the organic carbon in forest land soil. In order to calculate the annual increase in carbon in above-ground biomass (tC year^{-1}), the forested area in hectares (ha) is used for the emission factors presented in the 2006 IPCC Guidelines corresponding to each forest type and the vegetation it contains. The annual carbon stocks increase in biomass deriving from forest land is estimated for tropical rain forest, montane systems and dry forest. As regards forest emissions, only emissions resulting from the burning of biomass on forest land is considered

In accordance with the above, the NGGI does not take emissions associated with deforestation or forest degradation into account. In addition, the increase in biomass both for forests that remains as forest and for secondary forests is estimated. Emissions from deforestation (forest land converted to crops and pasture) and from degradation on land that remains as forest land are included with this method. Absorptions are estimated separately on land the remains as forest land and on land converted to forest land.

The country has just presented its Third Communication to the UNFCCC[150], in which forest emissions are reported using TIER 1 methodology (Ministry of Environment and Natural Resources, 2018)[151]. Through a GEF project, the Ministry is currently developing the Dominican Republic First Biennial Update Report (fBUR)[152]. The development of the fBUR does not envisage the inclusion of the FREL of the Emissions Reduction Programme[153]. The methodologies harmonisation process requires political approval for transition from Tier 1 to Tier 2 of the FREL of the ERP. To ensure consistency between the ER Programme FREL and the INGEI, the activity data and emission factors used in the RL will be consistently applied with those used to estimate the net INGEI.

Finally, in 2020 the Government will present the FREL/FRL to the UNFCCC. To ensure consistency between the ER Programme FREL and the FREL/FRL, the latter will be developed based on the information set out in the ERPD.

9 APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

The Measurement, Monitoring and Reporting (MMR) system of the ERP has three primary functions:

- Monitoring of the emissions reduction achieved by the ERP
- Monitoring of the multiple benefits: the monitoring indicators are i. Impact of the ERP on the conservation of biodiversity in endangered plants, ii. Impact of the ERP on the water resource and iii. Impact of the Green Jobs Programme
- Monitoring of safeguards: i. Natural habitats, ii. Forest, iii. Involuntary resettlement, iii. Natural and cultural resources and iv. Local communities

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[150] United Nations Framework Convention on Climate Change

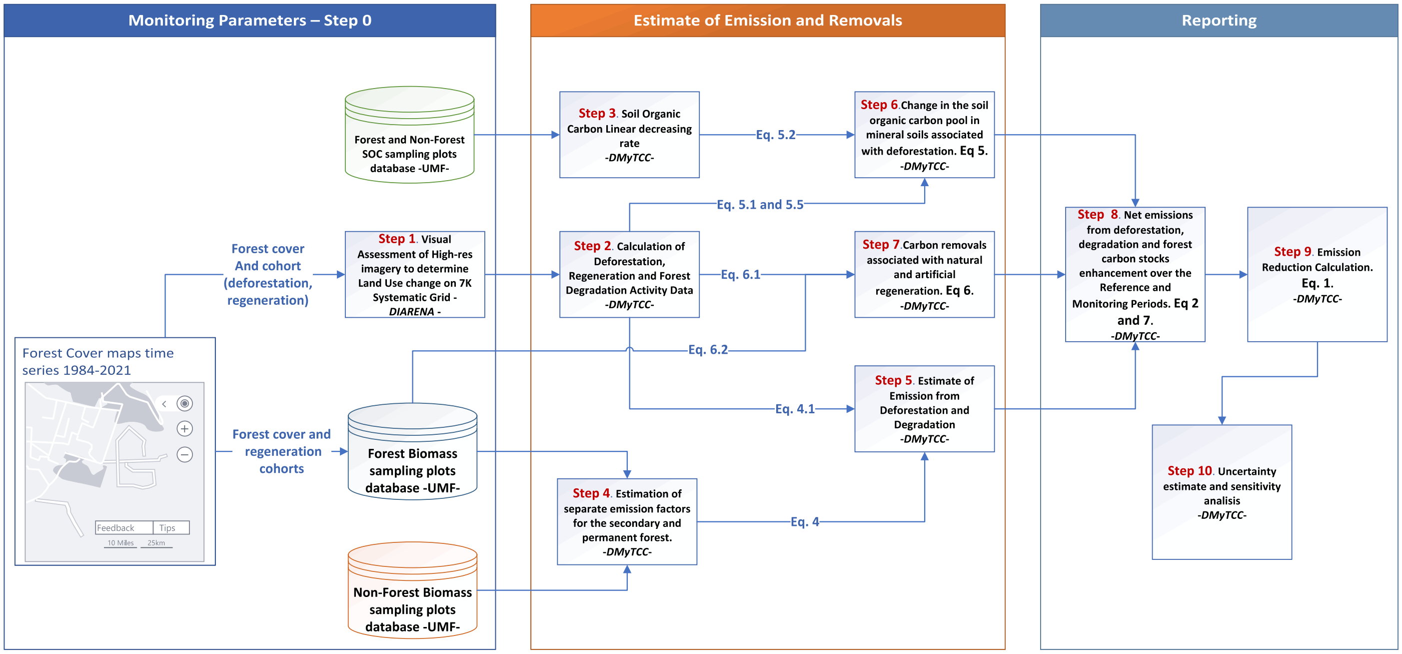
[151] Ministry of Environment and Natural Resources. (2018). Dominican Republic Third National Communication to the United Nations Framework Convention on Climate Change. 2014-2017.

[152] Dominican Republic First Biennial Update Report (fBUR). https://www.thegef.org/project/dominican-republic-first-biennial-update-report-fbur

[153] Personal communication, Rafael Beriguete, officer in charge of the fBUR at the Dominican Republic Ministry of Environment and Natural Resources.

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

Figure A4-9.1 shows a line diagram with relevant monitoring points, parameters, and data integration until reporting.



DIARENA: Dirección de Información Ambiental y Recursos Naturales
DMyTCC: Departamento de Métrica y Transparencia del Cambio Climático
UMF: Unidad de Momitoreo Forestal

Figure A4-9-1: Line diagram with monitoring parameters, equations, and the integration of data until reporting.

Calculation steps

Emission reduction calculation ($\mathrm{ER_{ERP,t}}$)

$$\mathrm{ER_{ERP,t}} = (\mathrm{RL_t} - \mathrm{GHG_t}) \times \frac{44}{12} \qquad \textbf{Equation 17}$$

Where:

$\mathrm{ER_{ERP,t}}$ = Emission Reductions under the ER Program in year t; $tCO_2e*year^{-1}$.

$\mathrm{RL_t}$ = Net emissions of the RL from over the Reference Period; $tCO_2e*year^{-1}$. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.

$\mathrm{GHG_t}$ = Monitored net emissions at year t; $tCO_2e*year^{-1}$;

$\frac{44}{12}$ = Conversion of C to CO2

Monitored emissions ($\mathrm{GHG_t}$)

Annual gross GHG emissions over the monitoring period in the Accounting Area ($\mathrm{GHG_t}$) are estimated as the in total biomass carbon stocks and organic carbon pool in mineral soils during the monitoring period.

$$GHG_t = \frac{\Delta C_{B_{MP}} + \Delta \mathrm{C}_{\mathrm{DegB}_{MP}} + \sum_{\mathrm{t}}^{\mathrm{MP}} \Delta \mathrm{C}_{\mathrm{RB}_{\mathrm{t}}} + \sum_{\mathrm{t}}^{\mathrm{MP}} \Delta \mathrm{C}_{Mineral_{\mathrm{t}}}}{T}$$ **Equation 18**

Where:

$\Delta \mathrm{C}_{\mathrm{B}_{\mathrm{MP}}}$ = Change in total biomass carbon stocks in forest lands converted to other land-use category during the monitoring period, in tC;

$\Delta \mathrm{C}_{\mathrm{DegB}_{RP}}$ = Change in total biomass carbon stocks in forest lands that remains as forest during the monitoring period, in tC;

$\Delta \mathrm{C}_{\mathrm{Mineral}_{\mathrm{t}}}$ = Annual change in the soil organic carbon pool in mineral soils associated with deforestation; tC*year^{-1};

$\Delta \mathrm{C}_{\mathrm{RB}_{\mathrm{t}}}$ = Annual change in total biomass carbon stocks in non-forest lands converted to forest lands categories at year t; tC*year^{-1};

T = Number of years during the monitoring period; dimensionless.

Change in total biomass carbon stocks in forest lands converted to other land-use (Deforestation):

Following the 2006 IPCC Guidelines, the annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta \mathrm{C}_{\mathrm{B}}$) is estimated through **Equation 3 4** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta \mathrm{C}_{\mathrm{B}_{MP}} = \sum_{\mathbf{j,i}} \left(\mathrm{B}_{\mathrm{Before,j}} - \mathrm{B}_{\mathrm{After,i}}\right) \times \mathrm{A(j,i)}_{\mathrm{MP}}$$ **Equation 19**

Where:

$\mathrm{A(j,i)}_{\mathrm{MP}}$ Area converted from forest type j to non-forest type i during the Monitoring Period, in hectares per year.

$$\mathrm{A(j,i)}_{\mathrm{MP}} = \frac{\mathrm{P(j,i)}_{\mathrm{MP}}}{\mathrm{N}} \times \mathrm{AA}$$ **Equation 9.1**

$\mathrm{P(j,i)}_{\mathrm{MP}}$: Number of points converted from forest type j to non-forest type I during the Monitoring Period, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program accounting area (in hectares)

In this case, ninety-six forest land conversions are possible resulted from the combinations of the following forest and non-forest types:

Forest type	Non-forest types
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest. Three canopy cover categories: • Intact forest (>85%). • Degraded forest (60-85%), and	Five types of non-forest land are considered: • Cropland. • Grassland. • Settlement; and • Woody vegetation.

- Very degraded forest (30-60%) Two cohorts of secondary forest - Cohort 4-21 years, and - Cohort 22-44 years.	

$\mathrm{B}_{\mathrm{Before,j}}$	Total biomass of forest type j before conversion/transition, in tons of C per ha. This is equal to the sum of aboveground biomass (AGB_{before}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{before}), litter (L_{before}) and death wood (DW_{before}) and it is defined for each forest type.
$\mathrm{B}_{\mathrm{After,i}}$	Total biomass of non-forest type i after conversion, in tons C per ha. This is equal to the sum of aboveground biomass (AGB_{after}) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass (BGB_{after}), litter (L_{after}) and death wood (DW_{after}) and it is defined for each of the five non-forest IPCC Land Use categories.

Change in the soil organic carbon pool in mineral soils associated with deforestation:

The matrices and **Equations 5, 5.1, 5.2, 5.3, 5.4,** and **5.5** used for determining the annual change in the soil organic pool associated with deforestation in the reference period will be also used for the monitoring period.

Carbon removals associated with natural and artificial regeneration, including plantations (Enhancement of forest carbon stocks):

The matrices **and Equations 6, 6.1, and 6.2** used to calculate annual carbon removals associated with regeneration in the reference period will be also used for the monitoring period.

Change in total biomass carbon stocks in forest lands that remains as forest (Forest Degradation):

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document, for applying IPCC Guidelines and guidance in the context of REDD+, the equation 2.16 of the 2006 IPCC GL can be simplified by assuming that the change in total biomass carbon stocks ($\Delta \mathrm{C}_{\mathrm{B}}$) is equal to the initial change in carbon stocks ($\Delta \mathrm{C}_{\mathrm{CONVERSION}}$). Thus, the change of biomass carbon stocks in forest lands that remains as forest during the Monitoring Period was also calculated with the **Equation 4**:

$$\Delta \mathrm{C}_{\mathrm{DegB}_{RP}} = \sum_{\mathbf{j,i}} \left(\mathrm{B}_{\mathrm{Before,j}} - \mathrm{B}_{\mathrm{After,i}}\right) \times \mathrm{Deg(j,i)}_{\mathrm{MP}}$$

Equation 9.2

Where:

$\Delta \mathrm{C}_{\mathrm{DegB}_{MP}}$	Change in total biomass carbon stocks in forest lands that remains as forest during the Monitoring period, in tC.
$\mathrm{Deg(j,i)}_{\mathrm{MP}}$	Area converted from forest with canopy cover j to forest with canopy cover i during the Monitoring Period, in hectares per year.

$$\mathrm{Deg(j,i)}_{\mathrm{MP}} = \frac{\mathrm{P(j,i)}_{\mathrm{MP}}}{\mathrm{N}} \times \mathrm{AA}$$

Equation 9.3

$\mathrm{P(j,i)}_{\mathrm{RP}}$: Number of points converted from forest with canopy cover *j* to forest with canopy cover *i* during the Monitoring Period, dimensionless.

N: Total of sampling point in the Systematic Grid used for the visual assessment of High-res imagery to estimate activity data.

AA: Emission Reduction Program accounting area (in hectares)

In this case, twenty-eight canopy cover transitions forest are possible resulted from the combinations of the following forest and canopy cover categories:

Forest type	Canopy cover category
Four forest types (forest present before 1984): • Wet broadleaf forest. • Dry broadleaf forest. • Pine forest, and • Mangrove forest. • Agricultural tree-shaded crops	Three canopy cover categories: • Intact forest (>85%). • Degraded forest (60-85%), and • Very degraded forest (30-60%) • Agricultural tree-shaded crops

$\mathrm{B}_{\mathrm{Before,j}}$	Total biomass of forest type *j* before transition, in tons of C per ha. This is equal to the sum of aboveground biomass ($\mathrm{AGB}_{\mathrm{before}}$) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass ($\mathrm{BGB}_{\mathrm{before}}$), litter ($\mathrm{L}_{\mathrm{before}}$) and death wood ($\mathrm{DW}_{\mathrm{before}}$) and it is defined for each forest type.
$\mathrm{B}_{\mathrm{After,i}}$	Total biomass of forest type *i* after transition, in tons of C per ha. This is equal to the sum of aboveground biomass ($\mathrm{AGB}_{\mathrm{after}}$) of trees with a diameter at breast high (dbh) higher than 2 cm, belowground biomass ($\mathrm{BGB}_{\mathrm{after}}$), litter ($\mathrm{L}_{\mathrm{after}}$) and death wood ($\mathrm{DW}_{\mathrm{after}}$) and it is defined for each forest type.

Parameters to be monitored

<table>
<tr><td>Parameter:</td><td>$A(j,i)_{MP}$; $A(j,i)_{LU}$, A(j) and $R(\mathrm{j,i})_{\mathrm{LU}}$</td></tr>
<tr><td>Description:</td><td>$A(j,i)_{MP}$: Area converted from forest type j to non-forest type i during the Reference Period, in hectares. Equation 9.1.
$A(j,i)_{LU}$: Area converted from forest type j to non-forest type i of the Land Unit LU, in hectares.
Equation 5.1.
A(j): Area of Stable Forest type j, in hectares Equation 5.5
$R(\mathrm{j,i})_{\mathrm{LU}}$: Area converted from non-forest type <i>j</i> to forest type <i>i</i> of the Land Unit LU, in hectares. Equation 6.1.</td></tr>
<tr><td>Data unit:</td><td>Hectares</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>More than 400 activity data are estimated for the calculation of annual net emissions from deforestation and forest regeneration: Deforestation (96 land conversion types), SOC change transitions (160 Land Units), Permanent Forest types (5 types), and Forest regeneration (160 transitions). A summary of activity data values by forest type is shown in the below tables.
Table 9-1: Deforested and Permanent Forest areas for the Reference Period 2006-2015.
<table>
<tr><th>Forest type</th><th>Deforested Area (ha) (TF-OT) Total Biomass emissions</th><th>Permanent forest (ha) (TF-TF)</th></tr>
<tr><td>Wet Broadleaf Forest</td><td></td><td></td></tr>
<tr><td>Dry Broadleaf Forest</td><td></td><td></td></tr>
<tr><td>Pine Forest</td><td></td><td></td></tr>
<tr><td>Agricultural Tree Crops</td><td></td><td></td></tr>
<tr><td>Mangroves</td><td></td><td></td></tr>
</table>
</td></tr>
</table>

Table 9-2: Deforested Area (ha) (TF-OT) for SOC inherited emissions calculation*.

Forest type	2016-2018	2019-2021	2022-2023	2024
Wet Broadleaf Forest				
Dry Broadleaf Forest				
Pine Forest				
Agricultural Tree Crops				
Mangroves				

**Activity data used to estimate SOC emissions does not include secondary forest loss area*

Table 9-3: Forest Gain 2006-2015 (ha) (OT-TF) for inherited removals calculation.

Forest type	2016-2018	2019-2021	2022-2023	2024
Wet Broadleaf Forest				
Dry Broadleaf Forest				
Pine Forest				
Agricultural Tree Crops				
Mangroves				

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

Spatial level of data: National

Sources of data: Sampling-based estimates and associated uncertainties were used to calculate the activity data. Annual activity data for deforestation and forest regeneration were derived from the systematic sampling procedure (7,697 Permanent Sampling Units).

Methods: Activity data estimate was made by applying the good practices and procedures identified by Olofsson et al. (2014) [154], GFOI (2016)[155] and GFOI (2021)[156]. The Dominican Republic MRV team prepared a Standard Operation Procedure for the sample-based REDD+ activity data estimation[157]. The same methods used to generate activity data for the reference level are used for the monitoring period, including the systematic 2.5 x 2.5 km grid, and the use of ***Permanent Sample Units*** (PSU) of one hectare (100 x 100 meters) with a single evaluation point corresponding to the plot centroid. PSUs are visually interpreted through time to ensure the ***temporal tracking of land use***. For the monitoring periods, land-use assessments are made for **2018, 2021, 2023, and 2024**. The 2018 assessment has the same land-use interpretation collected in the time series analysis for the reference level estimation

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[154] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

[155] GFOI. (2016). Integración de las observaciones por teledetección y terrestres para estimar las emisiones y absorciones de gases de efecto invernadero en los bosques. Métodos y orientación de la Iniciativa Mundial de Observación de los Bosques (Edición 2.). Roma: Organización de las Naciones Unidas para la Alimentación y la Agricultura.

[156] GFOI. (2021). Issues and good practices in sample-based area estimation.

[157] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

	(2000-2018). The Collect Earth Desktop (CED)[158] tool is used to perform the Multitemporal Visual Interpretation (MVI) during the monitoring period.
QA/QC procedures applied:	The photo interpretation of the reference points will be carried out by DIARENA specialists with extensive field experience. The same quality control and assurance procedures will be applied for the Monitoring Periods: i. Control of photo interpretation bias, ii. Control of variability between photo interpreters, iii. Data consistency control. These controls will be implemented by applying the protocol for the reference classification of spatial assessment units (SOP for the sample-based REDD+ activity data estimation)[159], discussed and agreed in advance with the personnel of DIARENA and the Forest Monitoring Unit. During the photo-interpretation process, a specialist with extensive experience will supervise the work of the analysts. The supervisor will review weekly deliveries of photo-interpreted points. This review will be focused on identifying and correcting errors and checking transition consistency and the years of change registered.
Uncertainty for this parameter:	The sources of uncertainty in the visual assessment of the systematic grid are associated with: i. **Sample size (density of the systematic grid):** original the land-use change estimate was based on 1,942 points. It was made a sampling intensification; now a systematic grid of 7,697 sampling points (2.5*2.5 km) is used to obtain activity data. ii. **Photo-interpretation of the land-use**: Bias in the photo interpretation of land use is controlled by means of criteria standardization and the establishment of decision trees for the visual assessment of high- and low-resolution images. In order to reduce variability between photo interpreters, prior to each monitoring event training exercises will be carried out using common samples, until satisfactory consistency is achieved. iii. **Quality of the images available for the purposes of assessing the land-use**: With the availability of Planet images on Collect Earth Online (http://collect.earth/), It is hoped that 100% availability of cloud-free images for all points on the systematic grid will be achieved.
Any comment:	Limitations to differentiate the mature and secondary forests present at the beginning of the reference period of the original methodological approach used to estimate DA and EF have been addressed. Based on Annual Canopy Cover maps information, mature and secondary forests present at the beginning of the reference period are differentiated. Also, separate emission factors for the secondary, intact, degraded, and high-degraded forest have been estimated.

Parameter:	$\mathrm{Deg(j,i)_{MP}}$:
Description:	$\mathrm{Deg(j,i)_{MP}}$: Area converted from forest with canopy cover j to forest with canopy cover i during the Monitoring Period, in hectares per year. **Equation 9.3.**
Data unit:	Hectares
Source of data or description	**Spatial level of data**: National

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

[159] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

Official Use

of the method for developing the data including the spatial level of the data (local, regional, national, international):	**Sources of data**: Sampling-based estimates and associated uncertainties will be used to calculate the activity data. Forest cover annual maps will be used as reference information to determine the canopy cover categories for each sampling point. **Methods:** Annual activity data for degradation and carbon enhancement in permanent forest will be derived from the systematic sampling procedure (7,697 Permanent Sampling Units) and Forest Cover (FC) annual maps. Activity data estimate was made by applying the good practices and procedures identified by Olofsson et al. (2014) [160], GFOI (2016)[161] and GFOI (2021)[162]. The Dominican Republic MRV team prepared a Standard Operation Procedure for the sample-based REDD+ activity data estimation[163]. FC maps provide a more robust determination of Canopy Cover than high-resolution imagery interpretation. Therefore, forest cover and its probability will be extracted from FC maps for each sampling point located in a permanent forest in the systematic grid to assign the canopy cover class 30-60%, 60-85%, and >85% for the later analysis of canopy cover change. Each pixel will be assigned to a canopy cover class if the probability of having a canopy cover above the threshold C was higher than 90%. Tree-canopy cover will be estimated through an automatic learning algorithm based on a model f of remotely sensed variables X in any location *I*, $\widehat{C_\iota} = f\left(X;\hat{\beta}\right) + \varepsilon$. $\widehat{C_\iota}$ is the percentage of a pixel (*i*)'s area covered by trees; β is a set of empirically estimated parameters; ε is residual error or uncertainty; and X is a set of measurements of surface reflectance, derived indices (NDVI, NDWI, and MNDWI) and metadata describing acquisition and sensor characteristics (Sexton et al.2013)[164]. This algorithm will be applied to the stack of Landsat images available for each year, to prepare the Dominican Republic annual canopy cover wall-to-wall raster maps from 2019 to 2024, with 30*30 m resolution; each pixel has a canopy cover value and the probability estimate. Further information on the preparation methods of canopy cover maps is detailed in Consultancy Report[165].

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[160] Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015

[161] GFOI. (2016). Integración de las observaciones por teledetección y terrestres para estimar las emisiones y absorciones de gases de efecto invernadero en los bosques. Métodos y orientación de la Iniciativa Mundial de Observación de los Bosques (Edición 2.). Roma: Organización de las Naciones Unidas para la Alimentación y la Agriculta.

[162] GFOI. (2021). Issues and good practices in sample-based area estimation.

[163] MIMARENA, 2019. Revisión de la propuesta de Protocolo de Evaluación Visual multitemporal para la obtención de datos de referencia para la estimación de la incertidumbre de los datos de actividad para el proceso REDD+. Programa Regional REDD+. GIZ. 26 p. https://app.box.com/s/l7f9k83zf5ssgutwtkc7w8a0hex834x8

[164] Sexton, JO, X-P Song, M Feng, P Noojipady, A Anand, C Huang, D-H Kim, KM Collins, S Channan, C DiMiceli & JR Townshend. 2013a. Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS continuous fields and lidar-based estimates of error. International Journal of Digital Earth 6: 427-448

[165] terraPulse, 2018. Estimation of Activity Data on Deforestation, Forest Degradation and Enhancement of Forest Carbon Stocks of Dominican Republic using Annual Time Series Analysis of Landsat data. Technical Document. 12 p. https://app.box.com/s/0i7wl8wss4l40mjl3299gfwpo4i7djoz

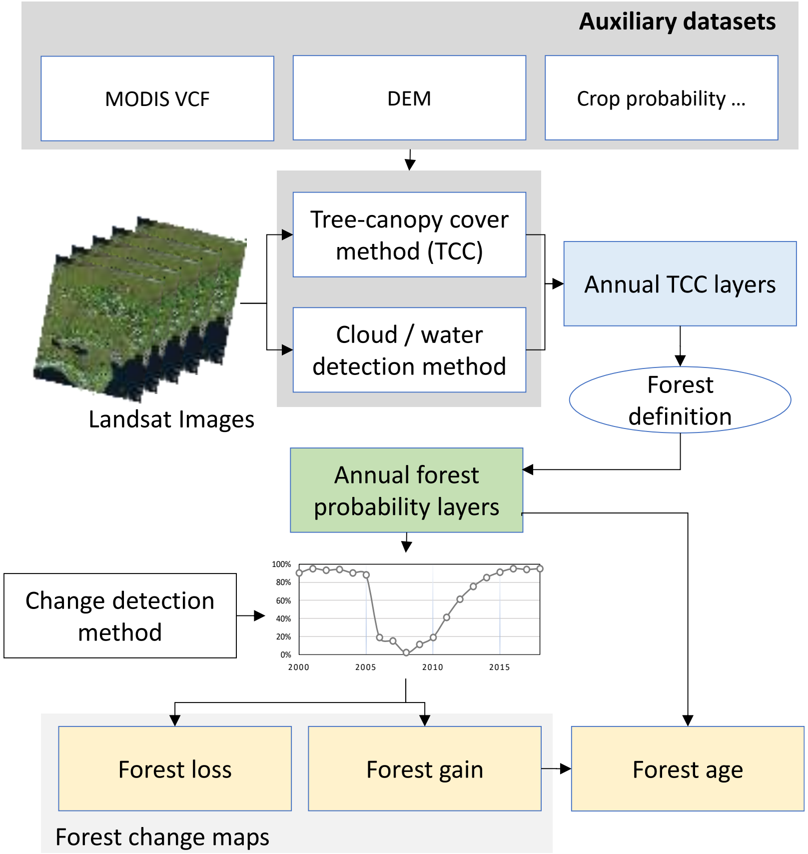

Figure 9-2. Estimation of percent-tree cover as a standard normal distribution of cover (mean) and uncertainty (standard deviation) in each pixel (Sexton et al. 2015)[166].

Value applied:

More than 48 activity data will be estimated for the annual emission of degradation and carbon enhancement in permanent forest. A summary of activity data values by forest type is shown in the following table.

Table 9-4: Canopy cover transition areas in permanent forest lands - 2019-2021

Canopy cover transition in permanent forest lands		**Annual Areas for 2019-2024 (ha)**
Wet Broadleaf Forest	Enhancement	
	Degradation	
Dry Broadleaf Forest	Enhancement	
	Degradation	
Pine Forest	Enhancement	

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[166] Sexton, JO, P Noojipady, A Anand, X-P Song, C Huang, SM McMahon, M Feng, S Channan & JR Townshend. 2015. A model for the propagation of uncertainty from continuous estimates of tree cover to categorical forest cover and change. Remote Sensing of Environment 156: 418-425

	Degradation	
Agricultural Tree Crops	Native forest	
Native forest	Agricultural Tree Crops	
Mangroves	Enhancement	
	Degradation	

QA/QC procedures applied

The same QA/QC procedures for deforestation and regeneration were applied to the estimate of degradation activity data. In this case, QA/QC procedures were focused on the interpretation of permanent forest areas.

Uncertainty associated with this parameter:

The canopy cover change category determination uncertainty for each sampling plot in the systematic grid was calculated at **6%** for degradation and canopy cover recovery classes[167]. This uncertainty was calculated by the bootstrap method, with 1000 simulations based on the bias estimate. The bias of the canopy cover in Forest Cover maps is 4.34%, with a standard deviation of 61.691. Likewise, the sampling error of estimating the areas of the canopy cover class change will be also calculated. Both uncertainties are included in the propagation error of the emission reduction calculation.

Table 9-5: Estimation error of canopy cover transition areas in permanent forest lands - 2019-2021

Canopy cover transition in permanent forest lands		**Annual Area for 2019-2024 (ha)**
Wet Broadleaf Forest	Enhancement	
	Degradation	
Dry Broadleaf Forest	Enhancement	
	Degradation	
Pine Forest	Enhancement	
	Degradation	
Agricultural Tree Crops	Native forest	
Native forest	Agricultural Tree Crops	
Mangroves	Enhancement	
	Degradation	

Any comment:

There are no comments.

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[167] The Excel tool used to estimate the canopy cover change category determination uncertainty by the bootstrap method can be accessed at the following link: https://app.box.com/s/ex2otzvkk4u32armla8rory8as9iu7tj

9.2 Organizational structure for measurement, monitoring and reporting

The Ministry of Environment and Natural Resources is the designated national authority and focal point for climate change. The organizational structure of the Emission Reduction Monitoring Report (ER-MR) is made up primarily of agencies of the Ministry of Environment: Department of Climate Change, Department of Environmental Information and Natural Resources (DIARENA), Forest Monitoring Unit "FMU", Department of Biodiversity and Wildlife and the Department of Social Participation. Figure A4-9-3 and Table 2.1 present roles and responsibilities of each of these agencies for collecting, processing, consolidating, and reporting GHG data and information.

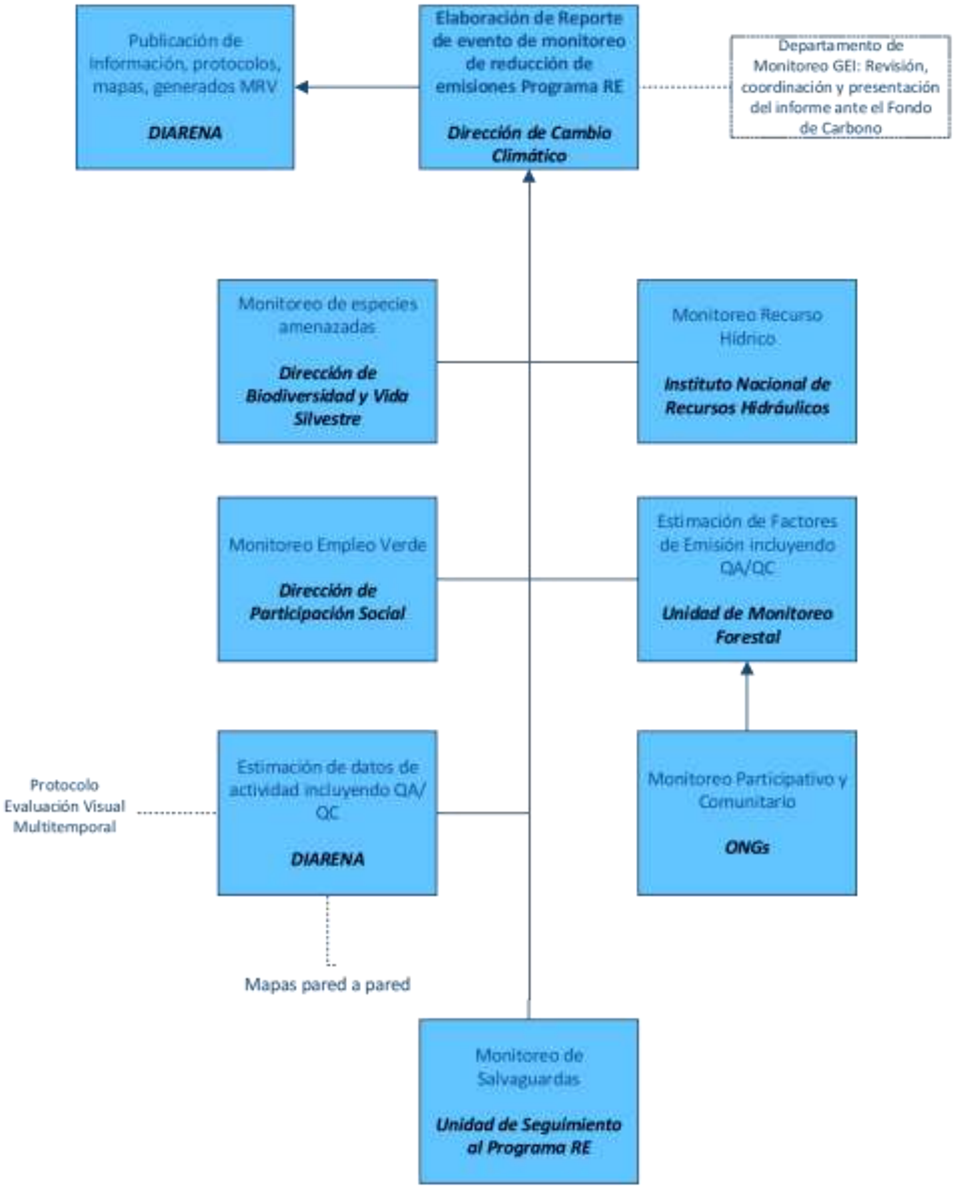

Figure A4-9-3: Organizational structure for ER-MR measurement, monitoring, and reporting in the Dominican Republic.

Table A4-9-6: Institutions in charge of the monitoring and reporting of the Emissions Reduction Program.

Monitoring function	Institution	Department	Technical team
Emissions reduction monitoring (Forest Monitoring system)			
Official reporting of emissions reduction to the Carbon Fund	The Ministry of Environment is the designated national authority and focal point for climate change	Coordinated by the Department of Climate Change of the Ministry of Environment	GHG Department (Revision, coordination and presentation of the ER Report to the Carbon Fund)
Publication of the information, protocols and maps generated in the monitoring system for the estimation of forest emissions reduction	Ministry of Environment	Environmental Information System, creation of REDD+ sub-portal operated by DIARENA (technical manager)	1 technical specialist
Estimation of emission and removal factors (including quality control and assurance and the management and estimation of uncertainty)	Ministry of Environment	Vice-Ministry of Forest Resources, Forest Monitoring Unit Estimation of rates of growth of secondary forest, forest fires, management plans	Forest Monitoring Unit 2 forest specialists, strengthening required (3 additional specialists). This team carries out the estimation of forest emissions for each monitoring event.
Estimation of activity data (including quality control and assurance and the management and estimation of uncertainty)	Ministry of Environment	DIARENA Generation of activity data and estimation of uncertainty, QA/QC	Technical team (3 remote sensing and GIS specialists). The technical team requires strengthening; a needs assessment is currently in progress.
Participatory and community monitoring	Non-Governmental Organizations Ministry of Environment	Forest Monitoring Unit (FMU)	NGO personnel Communities: monitoring of hot spots jointly with FMU 1 technician designated as Forest Monitoring liaison in 37 local offices, trained and equipped (instruments and equipment). (Office of the Minister of Environment)
Monitoring of multiple benefits			
Biodiversity (endangered species of flora)	Ministry of Environment	Department of Biodiversity and Wildlife	Ongoing monitoring programs
Water (INDRHI monitoring system)	INDRHI		63 telemetric water flow monitoring networks
Green Jobs	Ministry of Environment	Coordination by the Department of Social Participation	This requires institutional strengthening, and the Ministry of Labor must include this statistic
Monitoring of safeguards			
Natural habitats	Ministry of Environment	Monitoring Unit at the ERP.	Specialists from the Department of Social Participation 1 Social Specialist with responsibility for monitoring and following up on the MGAS and IRPF Support of the Technical Advisory Committee
Forest			
Involuntary resettlement			
Natural and cultural resources			
Local communities			

9.3 Relation and consistency with the National Forest Monitoring System

The institutional procedures and arrangements established for MMR will be used as the basis for the design and establishment of the National Forest Monitoring System, which will use the same methodologies; in fact, the MRV system of the ERPD is based on the national forest monitoring system.

12 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

12.1 Identification and assessment of sources of uncertainty

In the following table the country identifies and discuss in qualitative terms the main sources of uncertainty and its contribution to total uncertainty of Emission Reductions. The measures that have been implemented to address these sources of uncertainty as part of the Monitoring Cycle are also discussed.

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
Activity Data						
Measurement	✓	✓	**Land-use photo-interpretation**: Land-use visual assessment uncertainty is associated with the photo-interpretation consistency and the quality of the imagery dataset used for the assessment. Bias in the photo-interpretation of land use was mitigated by employing criteria standardization and decision trees for visual evaluation of high- and low-resolution images. Before each monitoring event, training exercises were carried out using common samples until satisfactory consistency is achieved to reduce variability between photo interpreters. During the land-use visual interpretation process, a specialist with extensive experience supervised the work of the analysts. The supervisor reviewed monthly deliveries of photo-interpreted points. This review focused on identifying and correcting errors and checking transition consistency and the years of change registered. According to QA/QC procedures, the minimum level of consistency between the analysts and the supervisor should be 90% on land-use interpretation Regarding imagery quality, Planet images on Collect Earth Online (http://collect.earth/) provided 100% availability of high-res cloud-free images for all sampling points on the systematic grid.	High	Yes	No
Measurement	✓	✓	**Canopy cover determination**: Canopy Cover was extracted from Tree Canopy Cover maps developed by terraPulse for each sampling point located in the permanent forest class in the systematic grid. TCC maps were used to mitigate the potential errors in canopy cover determination due to analyst interpretation bias or lack of hi-res imagery in the sampling plot. The uncertainty determination of the total sampling point assigned to each canopy cover change class was made with the bootstrap method, with 1000 simulations based on the bias estimate[168]. The bias of the canopy cover in Forest Cover maps is 4.34%, with a standard deviation of 61.691. Tree canopy cover reference data	Low	Yes	Yes

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[168] The Excel tool used to estimate the canopy cover change category determination uncertainty by the bootstrap method can be accessed at the following link: https://app.box.com/s/ex2otzvkk4u32armla8rory8as9iu7tj

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
			collected by the Dominican Republic team was overlaid with coincident terraPulse tree canopy cover estimates. The reference data from the terraPulse estimates were subtracted to calculate the bias of each terraPulse data point to estimate the bias. The scipy open-source python package (https://scipy.org) was used to fit a normal distribution of the terraPulse bias using Maximum Likelihood to estimate the mean and variance parameters.			
Representativeness	✓	✓	Sampling-based estimates and associated uncertainties were used to calculate the activity data. Annual activity data for deforestation, degradation, and forest regeneration were derived from the systematic sampling procedure (7,697 Permanent Sampling Units) to ensure the representativeness of the activity data estimate. However, due to time limitations, this report was prepared with only 6712 from the 7,697 sampling points of the systematic grid. The activity data required to prepare the ER-MR report includes two data sets: i. Reference Level consists of three subperiods 2000-2005, 2005-2015, and 2015-2018; ii. Monitoring Periods consist of four subperiods 2015-2018, 2018-2021, 2021-2023, and 2023-2024. The 2018 measurement is common to both activity data sets (Reference Level and Monitoring Periods); 2018 was reassessed in the monitoring period. Nine hundred eighty-five points, 13% of the 7,697 sampling points in the systematic grid, were not consistent between the two data sets. The availability of new high-resolution images in the 2022 measurement improved the interpretation of land use in 2018. It is essential to remember that activity data estimate for reference and monitoring periods is based on land-use tracking from 2000 to 2024. Any change in the 2018 measurement affects the evaluations made in the past (2000-2015) and the future (2018-2021-2023-2024). Revising the land-use interpretations and the transitions of the 985 inconsistent points in the two data sets (2000-2018 and 2018-2024) requires revisiting 4925 sampling points (985 points per evaluation date). These 985 sampling points are randomly distributed. The calculation of the activity data using only 6712 points varies between -8% and 15% concerning the estimate made with the 7697 points for the Reference Period. Also, the sampling error increases slightly, affecting the calculation of uncertainty. However, using only valid points excluded false positives in land-use transitions (reforestation and regeneration) from the estimation process.	Low	Yes	No
Sampling		✓	The density of the systematic grid was estimated from the analysis of 474 systematic sampling points collected by Ovalles (2018)[169]. According to this analysis, with a sample size of 1942, it is possible to achieve a standard error of global precision of S(ô) = 0.01. However, DIARENA established a 2.5 x 2.5 km grid with 7,697 sampling points to reduce the standard error in uncommon transitions.	High	Yes	Yes
Extrapolation	✓		Annual activity data for deforestation, degradation, and forest regeneration were derived from the systematic sampling procedure (7,697 Permanent Sampling Units). Activity Data were estimated with no stratification. No extrapolation of the AD estimate was necessary.	NA	NA	NA
Approach 3	✓		***Permanent Sample Units*** (PSU) of one hectare (100 x 100 meters) with a single evaluation point corresponding to the plot centroid was used for the land-use visual assessment. PSUs ensured the ***temporal tracking of land use***. Land-use assessments were made for 2000, 2005, 2015, 2018 and 201. The land-use class was interpreted with	Low	Yes	No

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[169] Ovalles, P. (2018). Elaboración de mapa de Uso y Cobertura del Suelo 2015. Análisis de Cambios y Mapa de Deforestación en la República Dominicana. Informe Final. Santo Domingo, República Dominicana.

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
			context and recorded for the individual pixel or point for t1 and t2. Using the land-use type at t1 and t2, the change class was determined for the pixel or point. Using single point Land-use change class information, areas of change were calculated for the population. Interpreters also collected the ***transition year*** in the PSUs with a land-use change registered between assessments.			
Emission Factors						
DBH measurement	✓	✓	Three sources of data were used to estimate total biomass in each of the land uses and the emission factors in the land-use change categories: a. The National Forest Inventory (**NFI**)[170], b Assessment of Biomass and Carbon Content in Non-Forest Cover in the Dominican Republic" (**ISNB**)[171], and c. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015 (**Technical Correction Inventory**) [172]. The three inventories were compiled using the same methodology, sampling unit, and nested plots in order to determine carbon density for each component recognized as a sink. Each carbon pool is estimated using the database at the tree level, taking the area of the sampling units into account. **NFI**: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[173] and QA/QC[174] procedures to reduce non-sampling errors. Since the beginning of the planning phase, courses on basic forest inventory techniques were given to 68 forestry technicians, half of them MARN officials and the other half personnel who work outside the Ministry. Then, three-day training workshops were held on INF-RD Field Manual, with the participation of 97 technicians selected. Subsequently, the crews responsible for the field survey were designated and received rigorous training in the Field Manual and the Quality Control Manual. **ISNB**: The MARN's Forest Monitoring Unit (UMF) developed a Field Manual[175] to reduce non-sampling errors. The crew members for the fieldwork received training for implementing inventory methodology and QA/QC procedures. The inventory methodology was explained, and field practices were carried out, including measurements and sampling exercises. During this training, the crew leaders were confirmed according to their abilities and capacities. **Technical Correction Inventory:** The quality control procedures during the implementation of the survey of the 32 additional plots have been made following the	Low	Yes	No
H measurement	✓	✓		High	Yes	No
Plot delineation	✓	✓		Low	Yes	No

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[170] Ministry of the Environment. 2015. Inventario nacional forestal de la República Dominicana: Measure and assess forests in order to understand their diversity, composition, volume and biomass. Field Manual. Forest Monitoring Unit. REDD7CCAD-GIZ. Regional Project 48 pages

[171] Ministry of the Environment. 2017. Assessment of the biomass and carbon content in non-forest systems in the Dominican Republic. Field Manual. Forestry Monitoring Unit REDD+ Preparation Project. 54 pages

[172]. Núñez, J.A.; Milla, F.; Navarrete, E. and Duarte. F. 2021. Collection of information required for the technical correction of the Forest Reference Level of the Dominican Republic, 2006-2015. LUKINVESTMENT SRL. Final Report. https://app.box.com/s/xfy8dkfil8c20gikcup3yf9846fifyt6

[173] MARN-GIZ. 2014. Manual de Campo del Inventario Nacional Forestal de la República Dominicana. Unidad de Monitoreo Forestal. Programa REDD CCAD GIZ. Santo Domingo, R.D. 61p. https://app.box.com/s/e0jf1lb49wpbd2981f9iwvvo2gvbf0av

[174] MARN-GIZ. 2018. Protocolo para el control de calidad del Inventario Nacional Forestal de Republica Dominicana 2018. Unidad de Monitoreo Forestal y Unidad de Gestión del Proyecto de Preparación REDD+ de la República Dominicana. 9p. https://app.box.com/s/b9uoly8bpn5n4b8xivhtv2ob3z2gslub

[175] MARN, 2017. Manual de Campo: Evaluación del contenido de biomasa y carbono en sistemas de No Bosque en la Republica Dominicana. Unidad de Monitoreo Forestal. Proyecto de Preparación de REDD+. 54p. https://app.box.com/s/056lacpm9rwyw2uh7a0aqz4a5yye9ol4

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
			NFI´s Field Manual and QA/QC procedures prepared by the Ministry of Environment and Natural Resources. The Forest Monitoring Unit of the Ministry has formed a quality control brigade that applied the QA/QC procedures in these additional plots; Likewise, the MARN QA/QC team and fieldwork crews were trained. Both teams worked together for two days, putting the inventory QA/QC protocol into practice.			
Wood density estimation	✓	✓	Wood density was obtained from the literature, mainly from Chave et al. (2006)[176]. Gender or family values were used for not-found species (genus/species). For species unknown or not found at any taxonomic level, all found species average density was used.	High	No	No
Biomass allometric model	✓	✓	There are no specific allometric equations for broadleaf forests in the Dominican Republic. Above-ground biomass (AGB) calculations are carried out using the allometric equations of Chave et al. (2014)[177] in the three inventories. For pine trees, a local allometric equation is used. Allometric equations developed in Nicaragua and Costa Rica are used for coffee, cocoa, coconut, mango, avocado, and guava. None of the non-local allometric equations are validated. The uncertainty of allometric equations was not propagated in the MC analysis. It is pending the propagation of this error in the MC simulation, increasing the sampling uncertainty of AGB and BGB by 10% at a 90% confidence level using the quadrature approach.	High	No	No
Sampling		✓	Sampling plots were randomly located. A total of 573 plots were collected, with estimations of the above-ground biomass (AGB), dead material (DM), and litter (L). This sample size allowed robust estimates of carbon densities for the different forest types (permanent and secondary) and non-forest land uses.	Low	Yes	Yes
Other parameters (e.g. Carbon Fraction, root- to-shoot ratios)			The Cairns et al. (1997) [178] equation is used to quantify below-ground biomass roots. In all inventories, the factor that is used to convert biomass to carbon content is the IPCC's default value (0.47).	High	Yes	No
Representativeness	✓		Based on Canopy Cover maps, a forest cover change analysis was prepared considering only pixels with> 90% probability of having a forest cover higher than 30%, 60%, and 85%. Subsequently, forest degradation classes and secondary forest cohorts were mapped into four categories: i. Intact Forest (>85% crown cover), ii. Degraded forest (60-85% crown cover), iii. Highly degraded forest (30-60% crown cover) and iv. Secondary Forest. All forest inventory plots in forest and tree-shaded crops were classified into these four categories based on terraPulse data. By forest type and degradation class, carbon content was directly derived from the biomass sampling plots database (average and 90%CI) to ensure the representativeness of carbon density estimates. Also, the mean annual carbon change in secondary forest and tree-shaded crops (tC/ha/yr.) was estimated by dividing the carbon change between non-forest and secondary forest land use by the time elapsed to reach the maximum biomass of the secondary forest type determined from the forest cover change maps.	Low	Yes	No
Integration						

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[176] **Chave, J. 2006.** Medición de densidad de madera en árboles tropicales. Proyectos Pan Amazonía - RAINFOR. 7 pp.

[177] Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, *20*(10), 3177–3190. https://doi.org/10.1111/gcb.12629

[178] Cairns, M. A., Brown, S., Helmer, E. H., Baumgardner, G. A., Cairns, M. A., Brown, S., … Baumgardner, G. A. (1997). Root Biomass Allocation in the World ’s Upland Forests. Oecologia, 111(1), 1–11. http://doi.org/10.1007/s004420050201

Source of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimate
Model	✓		Control Mechanisms of material errors have been included in emission and removal calculations tools; i.e., sums of sampling points by forest type coincide with sample size ensuring no double counting in the sample-based activity data estimate.	Low	Yes	No
Integration	✓		Activity Data and Emission Factors are fully comparable. Carbon densities have been estimated according to the forest types (permanent and secondary), and non-forest land uses interpreted in the visual assessment of hi-res imagery and Forest Cover maps.	Low	Yes	No

12.2 Quantification of uncertainty in Reference Level Setting

Parameters and assumptions used in the Monte Carlo method

Dominican Republic ER Program applied Monte Carlo methods (IPCC Approach 2) for quantifying the Uncertainty of the FREL/FRL. Because the MC propagation analysis includes more than 700 parameter values, it has been provided access to uncertainty and emission factor calculation tools to see all parameter values used in the analysis. The sources of uncertainty propagated in the Monte Carlo (MC) analysis are provided in the following Table.

Parameter included in the model	Parameter values	Range of Sampling Error / Standard Error / CI		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
Permanent Forest's Degradation and carbon Enhancement Activity Data	**Twenty-one** values for the Reference Period were included in MC analysis. See all values in the Uncertainty calculation tool[179], "Deforestacion y Degradacion" Sheet – (Reference Period cells A11..A58)	14%	1271%	The error of Tree Canopy Cover change classes (estimated with the bootstrapping method)[180] and Sampling Error of activity data estimate was included in Monte Carlo error propagation	Normal	Truncated Normal distribution (values > 0) was assumed for sample-based activity data estimate and the bias of Tree Canopy Cover maps.
Deforestation Activity Data	**Thirty** values for the Reference Period were included in MC analysis. See all values in the Uncertainty calculation tool "Deforestacion y Degradacion" Sheet – (Reference Period cells T59..T122)	712	2,844	Standard error of activity data estimate	Normal	Truncated Normal distribution (values > 0) was assumed for sample-based activity data estimate

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[179] Uncertainty calculation tool can be accessed at the following link: https://app.box.com/s/l2pwff1juz77xo4b4r4g48q2lj6ukdh9

[180] Error of Tree Canopy Cover change classes estimation tool can be accessed at the following link: https://app.box.com/s/ex2otzvkk4u32armla8rory8as9iu7tj

Parameter included in the model	Parameter values	Range of Sampling Error / Standard Error / CI		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
Activity Data for estimating SOC emissions associated with deforestation	The MC analysis included **167** Deforestation SOC Activity Data values and **4** values of Permanent Forest areas estimate. See all values in the Uncertainty calculation tool “EmisionesHeredadasSOC” Sheet – (Wet BL forest cells C23..C64; Dry BL forest cells C169..C210; Pine forest cells C315..C356; Tree-shaded crops cells C461..C502)	712	22,243	Standard error of activity data estimate	Normal	Truncated Normal distribution (values > 0) was assumed for sample-based activity data estimate
Activity Data for estimating inherited removals	The MC analysis included **442** Activity Data values for estimating inherited removals. See all values in the Uncertainty calculation tool “RemocionesHeredadas” Sheet – (Wet BL forest cells E25..Q62; Dry BL forest cells E78..Q115; Pine forest cells E131..Q167; Tree-shaded crops cells E184..Q220; Mangroves E237..Q274)	712	5210	Standard error of activity data estimate	Normal	Truncated Normal distribution (values > 0) was assumed for sample-based activity data estimate
Deforestation and Degradation Emission Factors	The MC analysis included **21** Carbon density values for forest types (secondary and permanent) and non-forest land uses categories considered in emission estimate. See all values in the Uncertainty calculation tool “FactoresEmision” Sheet – (cells G6..G26)	0.27	23.15	90% Confidence Interval of Carbon density estimate.	Normal	Truncated Normal distribution (values > 0) was assumed for all carbon density estimates.
Soil Organic Carbon Linear decreasing rate	The MC analysis included **4** SOC Linear decreasing rate values. See all values in the SOC Emission Factor calculation tool[181] “SOCEF” Sheet cells J7..J10.	19%	52%	Estimate error calculated combining uncertainty of SOC content before and after land-use transition with IPCC’s Approach 1 equation 3.2.	Normal	Truncated Normal distribution (values > 0) was assumed for SOC linear decreasing rate estimates.
Removal factors	The MC analysis included **8** Removal factors. See all values in the Carbon Densities calculation tool [182]“CarbonDensities” Sheet cells G45..G62.	16%	49%	Estimate error calculated combining uncertainties of non-forest land use and secondary forest carbon density with IPCC’s Approach 1 equation 3.2.	Normal	Truncated Normal distribution (values > 0) was assumed for Removal factors estimates.

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[181] The SOC Emission Factor calculation tool can be accessed at the following link: https://app.box.com/s/7gynk2iz594xtwgkptgabhco4jvo9vo8

[182] The Carbon densities calculation tool can be accessed at the following link: https://app.box.com/s/x4dhc9qynotu4rwmn82mulysneirvrhv

Quantification of the uncertainty of the estimate of the Reference level

		Deforestation	**Forest degradation**	**Enhancement of carbon stocks**
A	**Median**	-119,246	791,327	-1,871,896
B	**Upper bound 90% CI** (Percentile 0.95)	811,181	1,342,427	-1,564,673
C	**Lower bound 90% CI** (Percentile 0.05)	-1,109,573	388,707	-2,203,903
D	**Half Width Confidence Interval at 90% (B – C / 2)**	960,377	476,860	319,615
E	**Relative margin (D / A)**	**805%**	**60%**	**17%**
F	**Uncertainty discount**	**15%**	**8%**	**4%**

Sensitivity analysis and identification of areas of improvement of MRV system

The sensitivity analysis can be found in Section 5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS of this report.

Document history

Version	Date	Description
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.