Forest Carbon Partnership Facility (FCPF) Carbon Fund **ER Monitoring Report (ER-MR)**	
ER Program Name and Country:	Costa Rica
Reporting Period covered in this report:	*01-01-2018 to 31-12-2019*
Number of FCPF ERs:	3,283,023 t CO_2e*
Quantity of ERs allocated to the Uncertainty Buffer:	497,427 t CO_2e
Quantity of ERs to allocated to the Reversal Buffer:	182,390 t CO_2e
Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:	182,390 t CO_2e
Date of Submission:	*14-05-2021*
Version	3.0

* The number of FCPF ERs corresponds to the Substantial Volume reported by the Country as part of the conditions of effectiveness of the ERPA. Additional ERs are under legal analysis, and the country will present an updated volume of clear and uncontested ER on June 30th, 2022

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The Facility Management Team and the REDD Country Participant shall make this document publicly available, in accordance with the World Bank Access to Information Policy and the FCPF Disclosure Guidance.

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

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

Purpose of the ER-MR

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

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

Guidance on completing the ER-MR

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

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

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

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

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

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

Table of Contents

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: There are no changes or deviations in the ER Program's design and key assumptions compared to the description of the ER Program in the ER-PD. This section refers to FONAFIFO and SINAC's REDD+ actions implemented during the 2018-2019 period[2].

ACTION 1.1: Strengthen the operation and financing of SINAC's Forest Fires Management Strategy inside and outside Protected Conservation Areas: SINAC is implementing the National Fire Management Strategy 2012-2021 to provide integrated fire management with local and national government institutions, NGOs, the private sector, and civil society. SINAC also developed and implemented the Early Warning System for Forest Fires (SATIF) to predict fire occurrence and fire behavior nationwide. During 2018 -2019, SINAC implemented a yearly campaign of forest fire management at national, regional, and local levels and engaging the relevant actors such as brigades, private companies, local organizations, NGOs, and civil society. These campaigns focused on promoting the Guanacaste area, one of the most vulnerable regions to forest fires. SINAC also promoted the participation of volunteer forest firefighters' brigades. SINAC provided adequate training to the men and women firefighters. In 2019 the "First National Encounter of women Forest Firefighters assigned to the National System of Conservation Areas" was held.

ACTION 1.2: Strengthen the operation and financing of SINAC's Illegal Logging Control Strategy: SINAC controlled illegal logging activities in protected areas and supervised sustainable forest management activities. SINAC implemented two online systems to grant logging permits in private lands: a. System of Management Plans (SIPLAMA) for wood harvest in forest lands and b. Information System for the Control of Forest Use (SICAF) for logging permits in pasture and agricultural lands. SINAC also engaged different actors at the national level to promote participation in protecting and safeguarding natural resources in compliance with the national legal framework. During 2019, SINAC held a series of training workshops to reactivate COVIRENAS, aimed at local volunteers, on the use of integrated environmental reporting process systems (SITADA), among others.

ACTION 1.5: Contribute to the consolidation of SINAC's Protected Areas System: SINAC is designing and implementing robust strategies for administering and managing terrestrial and Marine Protected Areas, such as Natural Resource Management Plans, Sustainable Tourism Plans, and General Management Plans for Protected Wild Areas. SINAC also developed instruments to assess Protected Wild Areas' management effectiveness.

ACTION 1.4: Develop a strategy to integrate public lands to the State Natural Heritage: In 2019 SINAC created a System of Land Tenure Management in Natural State Heritage Lands with REDD+ readiness resources.

ACTION 5.2: Improve competitiveness of forestry and agroforestry financing mechanisms, also in relation to other land uses: FONAFIO implemented actions to promote natural regeneration through the Program of Payment for Environmental Services (PPES). FONAFIFO included the financial mechanisms to promote natural regeneration in the procedure manual of the PPES.

Update on the strategy to mitigate and/or minimize potential Displacement: The risk of displacement is still considered minimal in Costa Rica, as the ER Program's implementation area covers the national territory. Policies, actions, and measures of the REDD+ National Strategy continued to focus on strengthening incentives and policies without corrective measures. Also, the benefit-sharing plan increases and expands stakeholders' opportunity to receive benefits from REDD+ activities and thus eliminate risks to curb deforestation and forest degradation. FONAFIFO continued promoting forest protection; it had a significant boost to increase coverage in 2018 and 2019. A FONAFIFO´s Board agreement raised PES funds for forest protection. Most indigenous peoples participated through information, pre-consultation, and consultation mechanisms. Also, REDD governance operated satisfactorily.

Effectiveness of the organizational arrangements and involvement of partner agencies: In May of this year, the Government officialized[3] the SIMOCUTE (National Monitoring System for Land Use, Land Use Cover, and Ecosystems). SIMOCUTE is the official platform for coordination, linkage, and institutional and sectoral integration of the Costa Rican State, to facilitate the management and distribution of knowledge and information on land-use

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[2] See Policies, actions and activities included in the ER-P and the National REDD+ Strategy, in Table 4.3.1 of Emission Reduction Program Document.

[3] Decreto Ejecutivo N° 42886-MINAE-MAG-JP available at https://simocute.go.cr/wp-content/uploads/2021/05/LYD_Decreto-Firmas-No.-42886-MINAE-MAG-JP.pdf

change and ecosystem monitoring. The U.S. Forest Service, Silvacarbon, FAO, PNUD, and GIZ provided technical support and capacity building on MRV to CENIGA, IMN, and REDD+ Secretary of Costa Rica, allowing the country to complete the Emission Reduction monitoring report of the Emission Reduction Program.

Financial plan. The REDD+ National Strategy implementation plan requires an incremental investment of $95,362,967 to achieve REDD+ targets. A portion of this investment will be covered by the sale of emissions reduction with the Carbon Fund. However, more investment is required to complement activities within the Emissions Reduction Program. In this regard, the country is raising additional financial resources by accessing other carbon market mechanisms and instruments. In November 2020, the Green Climate Fund approved Costa Rica a $54.1 million Pay-per-Results project for 2014-2015 ERs.

1.2 Update on major drivers and lessons learned

By addressing drivers of forest loss, Costa Rica has demonstrated that emissions can be reduced effectively, as planned in the ER Program. Regarding degradation, it is necessary to implement adjustments to reduce its emissions. (see Table 1). Deforestation in Costa Rica has historically been driven by **the lack of ecosystem service value** that creates an incentive to convert forest land to agriculture and pasture. And **Lack of property rights** prevented small landowners and indigenous people from being incorporated into the existing payment for environmental services (PES) programs)[4]. There have not been any new deforestation drivers identified, and those listed above are now being addressed through the recently released (2020) Benefit Sharing Plan in the National REDD+ Strategy[5]. Costa Rica has established, expanded, and improved the financial mechanisms to strengthen natural reforestation and foster forest management. Costa Rica expanded the PES scheme to include indigenous territories, allowing indigenous peoples to influence and benefit from REDD+ activities in the country. Similar to the action above, there is no risk of leakage as this activity improves financial incentives for all landowners. Stakeholders in these lands were part of a consultative process that led to the implementation of a comprehensive government-led plan on socioeconomic and environmental safeguards[6], as well as the benefit-sharing mechanisms[7]. The emissions due to forest degradation have increased during the monitoring period (see Table 1). Forest degradation from illegal logging has been addressed since 2002. MINAE established strategies to control illegal logging and grant wood harvesting permits in agricultural lands, shifting the sources of Costa Rica's wood supply entirely. Now it is estimated that 49% of wood products come from forest plantations, 34% is imported, 12% is from agricultural lands, and 5% is from natural forests[8]. Costa Rica is addressing degradation through the financing mechanisms of PES and sustainable timber production initiative. No other degradation drivers have been identified.

Table 1. Comparison of the emissions and sinks in the reference period (1998-2011) and the pre-ERPA monitoring period (2018-2019).

Period	Average emissions from deforestation, t CO_2e/y	Average removals from reforestation (secondary forests), t CO_2e/y	Average emissions from degradation, t CO_2e/y	Average emissions from enhancements (forest remaining forests), t CO_2e/y	Net forest land cover change emissions, t CO_2e/y	Net forest remaining forests emissions, t CO_2e/y	Total net emissions, t CO_2e/y
Reference period (1998-2011)	5,985,795	-4,372,155	1,383,974	-411,896	1,613,640	972,078	2,585,717
Monitoring period, pre-ERPA (2018-2019)	840,167	-5,607,368	2,513,265	-403,491	-4,767,201	2,109,774	-2,657,427

[4] Plan de Implementación de la Estrategia Nacional REDD+ Costa Rica. Secretaria Ejecutiva REDD+ Costa Rica. 2017. Available at https://ceniga.go.cr/wp-content/uploads/2020/02/plan_de_implementacion_enreddcr.pdf

[5] Benefit Sharing Plan, National REDD+ Strategy. June 2020. Ministry of Environment and Energy (MINAE), Costa Rica. Retrieved from http://documents1.worldbank.org/curated/en/785151594625278269/pdf/Benefit-Sharing-Plan.pdf

[6] Resumen del Diseño del Sistema de Información sobre Salvaguardas REDD+ en Costa Rica. 2017. FONAFIFO. 80 pp. http://reddcr.go.cr/sites/default/files/centro-de-documentacion/propuesta_sis-redd_informe_final_-_fonafifo.pdf

[7] ibid 4.

[8] Santamaria et al. 2015. Mercado de la madera y derivados en Costa Rica. 216pp. https://onfcr.org/wp-content/uploads/media/uploads/documents/mercado-de-la-madera-y-derivados-en-cr-final.pdf

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

2.1 Forest Monitoring System

2.1.1 Organizational structure

Costa Rica's National Forest Monitoring System (NFMS), which generates information for the REDD+ Monitoring, Reporting, and Verification (MRV), has already been created following the Warsaw Framework for REDD-plus to access result-based payments. The country submitted NFMS for REDD+ to the UNFCC in November 2019[9]. The process started in 2015 when the National Center for Geospatial Information (CENIGA) initiated the designing process of the NFMS to cover all land uses and land-use changes at the national level, following IPCC's 2003 Good Practice Guidelines[10].

The NFMS is part of the SIMOCUTE platform (National Monitoring System for Land Use, Land Use Cover, and Ecosystems, see Figure 1). SIMOCUTE is the official platform for coordination, linkage, and institutional and sectoral integration of the Costa Rican State management and distribution of knowledge and information on land-use change and ecosystem monitoring (see Figure 2). SIMOCUTE provides technical guidance for the monitoring, reporting, and verification (MRV) of land-use change in the AFOLU sector (agriculture, forests, and other land use). SIMOCUTE is now a fully operational platform[11] that will integrate the MRV systems of GHG emissions from the AFOLU sector, including the national REDD+ program, the NAMAs, the national carbon trading system, and the progress of NDC implementation[12].

The NFMS is composed of two data collection mechanisms:

- The first is the Satellite Land Monitoring System (SLMS), which collects land use and land use change data. The agencies/institutions responsible for the SLMS are the National Meteorology Institute (IMN) and the REDD+ Secretariat, composed of the Fondo Nacional de Financiamiento Forestal (FONAFIFO) and the Sistema Nacional de Areas de Conservación (SINAC). The Instituto Metereológico Nacional (IMN) is also responsible for Costa Rica's National GHG Inventory (INGEI) and the development and submission of Biennial Update Reports (BURs). Therefore, the collaboration between IMN and FONAFIFO is crucial to maintain consistency between the REDD+ reporting and the national GHG inventory. The IMN is also tasked with developing indicators that follow IPCC's Good Practice Guidelines and SIMOCUTE´s structure.
- The second data collection mechanism is the National Forest Inventory (NFI), which gathers forest field data to estimate and update the country's emission factors. This piece of the NFMS is led by the SINAC, which is also responsible for promoting sustainable forest management, logging permits, and control of illegal logging.

Other government entities involved in the REDD+ Program are: Ministerio de Ambiente y Energia (MINAE), which gives political support to the process; Colegio de Ingenieros Agrónomos (CIAgro), which supervises forestry professionals in charge of REDD+ Program implementation; Oficina Nacional Forestal (ONF) is the interlocutor between these government entities and the private sector; and Asociaciones de Desarrollo Integral Indigena (ADII), which supports indigenous groups. The inter-institutional REDD+ Board of Directors is responsible for issuing policies, making decisions, and resolving conflicts or grievances related to REDD+.

[9] https://redd.unfccc.int/files/4863_2_sistema_nacional_monitoreo_forestal_costa_rica.pdf
[10] Available at: https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html
[11] Accessible at https://simocute.go.cr/
[12] https://simocute.go.cr/acerca/

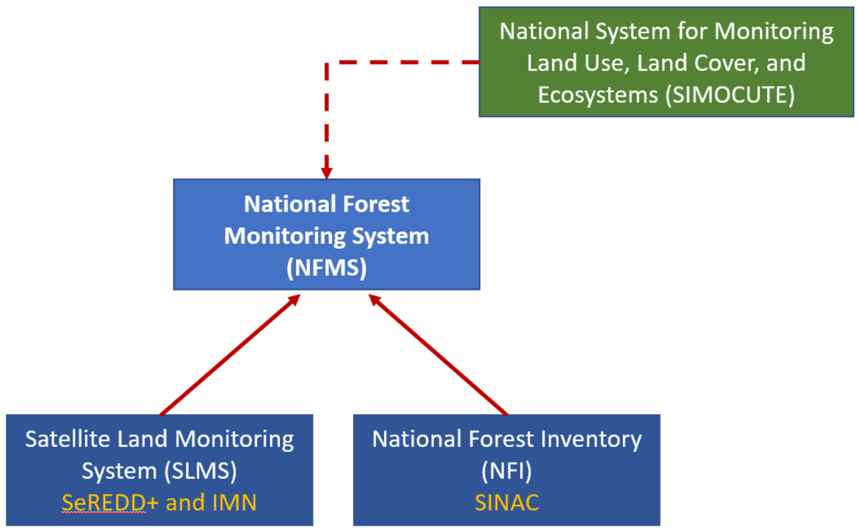

Figure 1. Organizational structure of the National Forest Monitoring System in Costa Rica.

Figure 2. Conceptual Framework of Costa Rica's SIMOCUTE (National Monitoring System for Land Use, Land Use Cover, and Ecosystems). Source: MINAE 2017.

REDD+ Secretariat counts with the support of the Costa Rica REDD-plus Result-Based Payments Project (RPB Project). This project will provide additional human resources and material inputs such as satellite imagery, hardware, software, and field monitoring equipment necessary for the Monitoring and reporting of REDD+ implementation. This activity will strengthen national capacities for REDD+ monitoring, reporting, and verification. Furthermore, this project will also provide support to meet the requirements of emerging market standards such as "The REDD+ Environmental Excellency Standard" (TREES) within the scope of the "Architecture for REDD+ Transactions" (ART) Program. RBP project will combine the market standards with Warsaw Framework for REDD+ results-based payments to maximize REDD+ financing for Costa Rica. Indeed, these standards can be made consistent with UNFCCC decisions for REDD+ while also including additional rules that reduce uncertainties and the risks of leakage and reversals. This activity will also support the verification of results by independent third parties. More specifically, this support will include

- Development and implementation of a diversified strategy for capturing REDD+ results-based payments from market and non-market sources based on international partnerships in line with the San Jose principles.
- Updating the FREL for a future submission, methodological improvements in response to technical assessment recommendations, and consolidating methodological consistency with the national GHG inventory and the NDC monitoring framework.
- Preparation of the second technical annex of REDD+
- Support for participation of Costa Rica in market mechanisms including the REDD+ Environmental Excellence Standard (TREES) of the Architecture for REDD+ transaction programme (ART).
- Support for validation and verification processes.

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

The processes for collecting, processing, consolidating, and reporting GHG data and information employed during the monitoring period will be identical to the ones used for the construction of the reference level. Costa Rica will monitor the same activities and carbon pools and will implement these same procedures for future monitoring events. The entities responsible for collecting, processing, consolidating and reporting GHG data and information are the following:

- **Obtaining activity data (AD):** Instituto Meteorológico Nacional (IMN) has produced to date all land use cover maps and national GHG inventories in Costa Rica. The REDD+ Secretariat has been the entity responsible for developing the land use cover maps for the historical series that were used to develop the FRL/FREL submitted to the UNFCCC.
- **Obtaining emission factors (EFs):** SINAC is responsible for Costa Rica's NFI, which determines regularly the forest stocks in the country. The NFI outcomes are used to develop emission factors for Costa Rica's REDD+ MRV. SINAC will update the NFI to allow future resampling of a portion of the existing plots, with the support of US Forest Service (USFS) and FAO, which will consist on a resampling of a portion of SIMOCUTE's 10,588 sampling plots. Costa Rica intends to start as soon as possible with the measurement of 441 sampling points over a 5-year period to estimate biomass transitions[13].
- **Estimating emissions and sinks:** IMN, responsible for the national GHG inventories in Costa Rica, maintains the capacity to estimate GHG from AFOLU (agriculture, forestry, and other land use) and LULUCF (land use, land use change, and forestry).
- **Reporting:** Technical reports and annexes on REDD+ are developed by the REDD+ Secretariat and supported by IMN experts estimating emissions and sinks. These include reports to the FCPF Carbon Fund (FC), safeguards reports, and BURs for payment for performance under REDD+. The results from these reports then undergo a verification process by external reviewers and the REDD+ secretariat along with the IMN work team must adjust the FREL/FRL as needed.

To calculate the average annual historical emissions over the reference period, Costa Rica followed an activity-based approach where emissions and removals are estimated based on spatially explicit gross activity data and on net emission factors. Activity data was entered in land use matrices (see below) to ensure representation of all land use transitions and avoid double counting or omissions.

[13] MINAE, 2019. Technical Annex of the Republic of Costa Rica, in accordance with the provisions of Decision 14 / Cp.19. 64pp. Retrieved from https://unfccc.int/sites/default/files/resource/4863_3_iba-2019-anexotecnico_Edited.pdf .

	FL	LCFL	CL	GL	SL	WL	OL
FL	*CO*	*NA*	*DF.1*	*DF.1*	*DF.1*	*DF.1*	*DF.1*
LCFL	*EC.3*	*EC.2*	*DF.2*	*DF.2*	*DF.2*	*DF.2*	*DF.2*
CL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
GL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
SL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
WL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
OL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*

***FL**, Forest Land; **LCFL**, Land Converted to Forest Land; **CL**, Cropland, GL, Grassland; **SL**, Settlements; **WL**, Wetlands; **OL**, Other Land; **CO**, Conservation of forest C stocks; **EC**, Enhancements of forest C stocks (.1, EC in conversions of non-forest land to forest land; .2, EC in LCFL remaining LCFL; .3, EC in LCFL converting to FL); **DF**, Deforestation (.1, DF of old-growth forests; .2, DF of secondary forests); **NA**, Not Applicable in the REDD+ context.*

Once AD and EFs for the forest that remain forests and forest cover change are generated and the corresponding GHG fluxes estimated with excel-based calculators, the uncertainty of the estimates is assessed by IMN and technical advisors from academia as needed (Figure 3).

To develop NFMS methods and protocols, SIMOCUTE follows the UNFCCC AFOLU requirements for monitoring land use cover emissions and establishes technical working groups to determine the procedures to implement methodologies and protocols, as well as to update them if needed. These technical working groups are conformed by experts from the institutions involved in the monitoring of ecosystems and land use / land cover.

The key elements of the SLMS and the NFI, including the source of data, the forest area covered, and the frequency of monitoring can be found in the Technical Annex Document[14]. There are QA/QC procedures for the AD and FE calculation as follows:

- **Activity Data:** The QA/QC procedures applied during the calculation of AD for the reference and monitoring period are summarized in Tables 2, 3, 6, and 7, further information may be found in Agresta (2005)[15], Ortiz-Malavassi (2017)[16], and Aguilar (2020)[17].
- **Emission Factors:** The QA/QC procedures applied during the calculation of EF for deforestation and degradation are summarized in Tables 4 and 5, further information may be found in Ministerio de Ambiente y Energía (2015)[18], Rodriguez (2018)[19], Coto (2018)[20], and Obando (2019)[21].

Costa Rica's first National Forest Inventory (NFI) was finished in 2015, under the supervision of SINAC. The NFI plots have been found to pose challenges for SINAC to conduct forest change assessments over time because of an uneven

[14] MINAE, 2019. Technical Annex of the Republic of Costa Rica, in accordance with the provisions of Decision 14 / Cp.19. 64pp. Retrieved from https://unfccc.int/sites/default/files/resource/4863_3_iba-2019-anexotecnico_Edited.pdf .

[15] Agresta, Dimap, Universidad de Costa Rica, Universidad Politécnica de Madrid. 2015. Final Report: Generating a consistent historical time series of activity data from land use change for the development of Costa Rica's REDD plus reference level: Methodological Protocol. Report prepared for the Government of Costa Rica under the Carbon Fund of the Forest Carbon Partnership (FCPF). 44 pp. https://www.dropbox.com/s/ygjw6zq00a1qtbm/Informe_tecnico_feb_2015.pdf?dl=0

[16] Ortiz-Malavassi, E. (2017). Evaluación Visual Multitemporal (EVM) del Uso de la tierra, Cambio en el Uso de la Tierra y Cobertura en Costa Rica Zonas A y B Tarea 1: Estimación del área de cambio de uso de la tierra durante el periodo 2014-2015. Retrieved from https://drive.google.com/file/d/1GXdN43f-DNKelkM8y7gBLrKou-f7LI-G/view?usp=sharing

[17] Aguilar, L. (2020). Evaluación Visual Multitemporal para la determinación de la degradación forestal para los periodos 2014-2015-2017-2019 y determinación de datos de referencia para periodo 2017-2019. Tercer Informe. Retrieved from https://drive.google.com/file/d/1ERutZo6vNI6MXUCmlrky7wiaeOqOLMqh/view?usp=sharing

[18] Ministerio de Ambiente y Energía. (2015). Volumen 4 Marco conceptual y metodológico para la Inventario forestal nacional de Costa Rica. Retrieved from https://www.sirefor.go.cr/pdfs/Volumen4-MarcoC-Imprenta.pdf

[19] Rodríguez, J. (2018). INFORME FINAL DE CONSULTORÍA Estudio de parcelas temporales para estimar el stock de carbono en bosques intactos, degradados y altamente degradados en zona A. (Contrato N°020-2018-REDD). Retrieved from https://drive.google.com/file/d/1dSyL8Dldwym5VN1jXpnAbmPovUW3AiTu/view?usp=sharing

[20] Coto, O. (2018). INFORME FINAL DE CONSULTORÍA. Estudio de parcelas temporales para estimar el stock de carbono en bosques intactos, degradados y altamente degradados en zona B. (Contrato N°019-2018-REDD). Retrieved from https://drive.google.com/file/d/1svYPJGEoBHpLn72sg4ejpf6uZkp6lllM/view?usp=sharing

[21] Obando, G. (2019). COORDINACIÓN GENERAL DE LA IMPLEMENTACIÓN DEL PLAN DE MEJORA DEL NIVEL DE REFERENCIA. Tercer Informe de Consultoría N ° 016-2018-REDD. Retrieved from https://drive.google.com/file/d/1MEHZ6dvQKY52X58UtlG02o4Uw9x1HV6v/view?usp=sharing

plot distribution among forest strata[22] and thus, SINAC is currently evaluating changes to the NFI structure through redistributing the plots to enhance compatibility with SIMOCUTE.

2.1.3 Role of communities in the forest monitoring system:

The NFMS, conceived as an official information system, must adhere in its design and function to the current standards applicable to the processes of generating official information, which are regulated by several corresponding entities: The National Geographic Institute (IGN) and its national territorial information systems, the National Institute of Statistics and Census (INEC) regarding data usage, etc. That is why in principle, community participation is not expected in these systems, unless it becomes necessary at some points to fill gaps in the generation of data that may involve these forms of participation.

However, ER-Program envisions supporting measures lead to robust participation by communities and organizations in control actions related to forest resources. For example, SINAC efforts to strengthen the involvement of communities in firefighting through the so-called "Forest fire brigades" that are mainly composed of volunteers in zones with high susceptibility to these phenomena (see section 1.1). Also, SINAC efforts to strengthen the "Natural Resources Monitoring Committees" (COVIRENAS) and the activities of the Volunteers Association (ASVO), non-government entities that contribute through different activities coordinated with the appropriate government agencies, monitoring compliance with government legislation, in the first case, and in supporting the management of protected areas in the second.

SINAC engaged different actors at the national level to promote participation in protecting and safeguarding natural resources. It is a mechanism that allows state institutions responsible for ensuring these resources to establish surveillance actions together with communities in compliance with the national legal framework. During 2019, SINAC held a series of training workshops to reactivate COVIRENAS, aimed at local actors interested in their formation, and training in the use of integrated environmental reporting process systems (its acronym in Spanish is SITADA), among others.

In addition to this, the Colegio de Ingenieros Agrónomos (Agronomists' Association) as the governing entity of the "Certified Foresters" who are responsible for preparing and following-up on the management plans of the different modalities of payment for environmental services agreements, have an essential task in monitoring the beneficiaries´ compliance with their respective commitments or actions they have agreed to take with regard to conservation, restoration, reforestation or management. In that same sense, there are many local and regional forestry producer organizations that provide regency services to interested parties, and that have their capacities strengthened through PES. It is envisioned to strengthen these capacities through different lines of work incorporated in policies, actions and tasks of the PRE.

2.2 Measurement, monitoring and reporting approach

2.2.1 Line Diagram

The diagrams below show a step-by-step description of the measurement and monitoring approach applied for establishment of the Reference Level and estimating Emissions and Emissions reductions during the Monitoring / Reporting Period for estimating the emissions and removals from the Sources/Sinks, Carbon Pools and greenhouse gases selected in the ER-PD (Figure 2).

[22] Recomendaciones para la Medición, Reporte, y Verificación (MRV) de REDD+. 2016. Report from the CDI, US Forest Service, and FAO UN-REDD. 33 pp.

Costa Rica has developed a tool to estimate emission and removals from deforestation and reforestation - FREL & MRV TOOL CR.xlsx[23], and other for the estimate of emission and removals from degradation in permanent forest lands – Herramienta-degradacion.xlsx[24].

FREL tool: Details of FREL tool can be found in START spreadsheet, and its manual (Manual de la Herramienta FREL & MRV Tool – UNFCCC.pdf in Spanish[25]). The tool is organized in the following sections:

Setting sections that must not be modified by users:

i. START: This spreadsheet explains the general information of the Tool: i. name and contact information of the person who made the last modification of the Tool, ii. date of the changes and iii. keyword used to lock spreadsheets.

ii. FREL&FRL: In this spreadsheet the user can recalculate the FREL/FRL by selecting i. carbon gases and reservoirs to be included in the FREL/FRL; ii. REDD + activities to be included in the FREL/FRL; iii. the years of the historical reference period of the FREL/FRL.

iii. C-STOCKS: The objective of this spreadsheet is to calculate the carbon stocks (in tCO_2-e ha^{-1}) of the land use categories represented in the Land Cover Maps (MCS) of Costa Rica. The calculation is done separately for each gas and carbon pool, whether or not it is included in the FREL/FRL. The spreadsheet also reports uncertainty values, at 90% or 95%, associated with estimates of average carbon existence. The calculations of these uncertainty values are made in a separate Excel file ("Carbon Database> 4. Carbon Densities"[26]) using the IPCC uncertainty propagation method (Equation 3.1 and 3.2 of IPCC-GL, 2006 - Volume 2). At the end of the spreadsheet, all the data, parameters and default values used in the calculation of carbon stock estimates and their respective sources are listed.

iv. REDD+ ACT: This spreadsheet defines REDD + activities in such a way that it is not possible to count the same source or the same GHG sink in more than one REDD + activity and ensuring, at the same time, that all GHG sources and sinks are considered in the analysis. The approach taken to meet this objective is to represent in a matrix of land use changes all possible transitions between land use categories and then assign each cell in the matrix to a single REDD + activity.

v. LIST: This spreadsheet contains the drop-down lists that appear in the rest of the Tool's pages and additional information related to the stratification of Costa Rica's forests. No calculation is made on this sheet.

Input section:

vi. LCM AAAA-AA: In this spreadsheet the activity data of the "AAAA-AA" period are reported, where "AAAA and AA" are the beginning ("AAAA") and end ("AA") years of the period. This is done by filling in a matrix of land use changes with all possible transitions. The structure of the matrix is identical to the matrix presented in the "REDD + ACT" spreadsheet, which allows the activity data to be related to REDD + Activities.
The "LCM AAAA-AA" spreadsheets are the only ones that must be filled in for REDD + monitoring. When activity data is entered in the matrices of the "LCM AAAA-AA" sheets, the Tool will automatically calculate the annual activity data ("AD AAAA" sheets) and annual emissions and removals ("ER AAAA" sheets) up to the "AA" year (= last year of the "AAAA-AA" period). The "FREL & FRL" sheet will be updated with the data calculated up to the "AA" year and the results of the mitigation actions (or emission reduction program) on the "RESULTS" sheet.

Calculation section:

vii. AD AAAA: In this sheet the annual activity data are calculated from the values entered in the "LCM AAAA-AA" sheets. The calculation is made in matrices of land use changes and is based on the assumption that in the "AAAA-AA" period the areas converted annually are equal.

[23] The FREL Tool can be accessed in the following link:
https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing
[24] Degradation tool can be accessed in the following link:
https://drive.google.com/file/d/1GG3Z_QMWBKGNRdXnF_TdWP1ipH9dX5iH/view?usp=sharing
[25] A copy of the FREL Tool Manual can be download at the following link:
https://drive.google.com/file/d/14CsE_rpBBrEJgyUTplziKKsGGVm_YtL_/view?usp=sharing
[26] A copy of Carbon Densities database can be download at the following link:
https://drive.google.com/file/d/1LJ8pbd0EuiVoS7JuMc8ps_OwlD12MUuH/view?usp=sharing

viii. ER AAAA: These spreadsheets calculate GHG emissions and removals related to the land use change summarized by type of forest and REDD + activities. The calculation is performed automatically in each of the cells of the land use change matrices by multiplying the activity data by their corresponding emission factors. The activity data are the values calculated in the matrices of the "AD AAAA" spreadsheets. The emission factors are calculated as the difference between the carbon contents existing at the beginning and end of the year, taking the carbon stock values of the "C-STOCKS" spreadsheet.

Results sections:

ix. RESULTS: This spreadsheet calculates and shows the results of the mitigation action. Results are calculated considering the same gases, carbon reservoirs, emission factors and REDD + activities that were included in the FREL / FRL. The calculation of the results is simply the difference between the actual emissions / removals and the emissions / removals of the FREL/FRL.

x. CHARTS: This spreadsheet contains graphs and tables that were included in the FREL / FRL description documents of Costa Rica that were submitted to the UNFCCC (MINAE, 2016). The content of this sheet is informative and there are no parameters that the user can change (except the working language) or calculations that are not performed on other spreadsheets.

Uncertainty analysis are performed in a separated tool using Monte Carlo simulation as described in section 5.

Degradation tool: Costa Rica used a methodology of visual interpretation of high-resolution images to detect changes in the canopy of permanent forest areas to estimate emissions and removals from degradation. This analysis resulted in a database of canopy cover percentages in 4,377 points in forest lands of Costa Rica for several years. Details of the Degradation tool can be found in Winrock International, (2018)[27]. The tool facilitates the following calculations:

- Segregation of interpretation points between anthropic and natural carbon flux areas to eliminate natural changes from emissions accounting since the ER program cannot control them.
- Calculation of the number of points in each forest state transition. In this step, the canopy interpretation assessment of the three forest status classes of the initial year and the final year of the monitoring period are classified. The three classes of forest status are: a. Intact: forest areas with canopy percentage between 85-100%; b. Slightly degraded: forest areas with canopy percentage between 60-85%; c. Very degraded: forest areas with canopy percentage less than 60%.
- Extrapolate the area of each transition of forest states. This step is necessary to extrapolate the carbon flows detected at the interpretation points to the entire permanent forest area for the monitoring period.
- Calculation of the average canopy percentage for each forest state. In this step, the tool calculates the average canopy percentage of each forest state for the beginning and the end of the monitoring period.
- Estimation of carbon fluxes (emissions and removals) of each type of transition is the final step. The tool uses the relationship between the percentage of canopy cover and biomass to estimate carbon fluxes in each transition from forest state.

The Degradation tool is organized as follows:

i. Descripcion_Variables: This sheet contains descriptions of the High-Resolution Image Visual Interpretation Analysis database attributes. Take note of the attributes *Arbol+Palma_AAAA* variables. These attributes show the percentage of canopy cover in the initial and final year of the monitoring period.

ii. Base_de_Datos: This sheet contains the database for the visual interpretation of high-resolution images.

iii. Resumen_de_puntos: This sheet calculates the number of points and extrapolates the area for each transition from the forest state.

iv. Deg_ems_antro_RP_AA-AA: This sheet calculates the average canopy percentage of each forest state and the anthropic carbon fluxes (emissions and removals) of each type of transition for the Reference Period.

v. Deg_ems_nat_RP_AA-AA: This sheet calculates the average canopy percentage of each forest state and the natural carbon fluxes (emissions and removals) of each type of transition for the Reference Period.

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[27] Winrock International. (2018). Ejercicio : estimación de emisiones por actividades en bosques que permanecen como tales. Retrieved from https://drive.google.com/file/d/1Mk8MACXEKDROXQg2UP7t4FDqQmc8Q5S9/view?usp=sharing

vi. Deg_ems_antro_MP_AA-AA: This sheet calculates the average canopy percentage of each forest state and the anthropic carbon fluxes (emissions and removals) of each type of transition for the Monitoring Period.

vii. Deg_ems_nat_MP_AA-AA: This sheet calculates the average canopy percentage of each forest state and the natural carbon fluxes (emissions and removals) of each type of transition for the Monitoring Period.

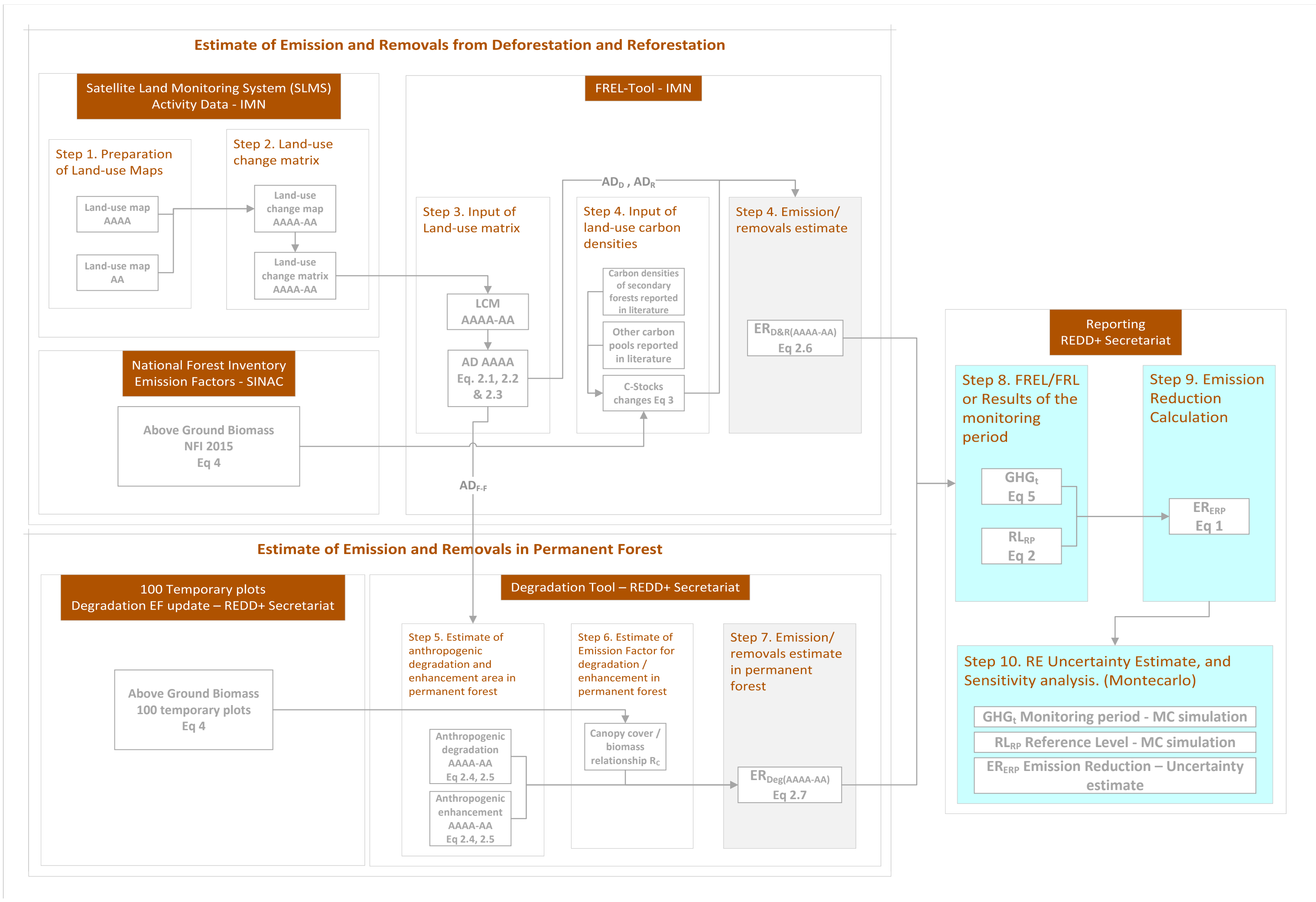


Figure 3: Step-by-step description of the measurement and monitoring approach applied for establishment of the Reference Level and estimating Emissions and Emissions reductions during the Monitoring / Reporting Period for estimating the emissions and removals from the Sources/Sinks, Carbon Pools and greenhouse gases selected in the ER-PD of Costa Rica. In this 2018-2019 monitoring report Costa Rica includes the update of the emission factors for degradation for the main forest types in the country (wet and rain forests, moist forests, dry forests, mangrove forests, and palm forests). This update is based on the 100 temporary plots sampled for aboveground biomass in 2018-2019. The details of this update are provided in the sections below.

2.2.2 Calculation

2.2.2.1 EMISSION REDUCTION CALCULATION

$$ER_{ERP,t} = RL_{RP} - GHG_t$$ **Equation 1**

Where:

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

RL_{RP}	=	Gross emissions of the RL from deforestation and degradation over the Reference Period; $tCO_2e*year^{-1}$. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.
GHG_t	=	Monitored gross emissions from deforestation at year t; $tCO_2e*year^{-1}$;
t	=	Number of years during the monitoring period; dimensionless.

2.2.2.1.1 Reference Level ($\mathbf{RL_t}$)

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

$$RL_{RP} = \frac{\sum_{t=1}^{RP} ER_{RA_t}}{RP} = \frac{\sum_{t=1}^{RP} \sum_{i=1}^{I} \left(AD_{RA_{i,t}} * EF_{RA_{i,t}}\right)}{RP}$$

Equation 2

Where:

ER_{RA_t}	=	Emissions or removals associated to REDD+ activity *RA* in year *t*; tCO_2-e yr^{-1}
$AD_{RA_{i,t}}$	=	AD associated to REDD+ activity *RA* for the land use transition *i* in year *t*; ha yr^{-1}
$EF_{RA_{i,t}}$	=	EF associated to REDD+ activity *RA* applicable to the land use transition *i* in year *t*; tCO_2-e ha^{-1}
RP	=	Reference Period in years
i	=	A land use transition represented in a cell of the land use change matrix; dimensionless
I	=	Total number of land use transitions related to REDD+ activity *RA*; dimensionless
t	=	A year of the historical period analyzed; dimensionless

Deforestation and Reforestation Activity Data (**AD_D** and **AD_R**) are calculated differently from Degradation and Enhancement Activity Data (**AD_{Deg}** and **AD_E**). Deforestation and Reforestation ADs result from the cartographic comparison of land-use maps from the beginning and end of the monitoring period. The Degradation and Enhancement DAs result from the sample-based estimation of canopy change area in permanent forest lands. Below are the equations used to calculate these parameters:

Activity Data of Deforestation (AD_D)	$AD_{D_{i,t}} = \lvert D_{i,t} \rvert * 0.81$, **Equation 2.1**	Where $\lvert D_{i,t} \rvert$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Activity Data of Reforestation (AD_R)	$AD_{R_{i,t}} = \lvert R_{i,t} \rvert * 0.81$, **Equation 2.2**	Where $\lvert R_{i,t} \rvert$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Forest remaining forests (AD_{F-F})	$AD_{F-F_{i,t}} = \lvert F - F_{i,t} \rvert * 0.81$, **Equation 2.3**	Where $\lvert F - F_{i,t} \rvert$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Activity Data of Degradation (AD_{Deg})	$AD_{Deg_k} = \frac{\lvert Deg_k \rvert}{N} * AD_{F-F_t}$ **Equation 2.4**	Where $\lvert Deg_{i,t} \rvert$ is the count of sampling points where canopy change decrease (dimensionless) in forest type k, *N* is the total of sampling points (dimensionless), and AD_{F-F_t} is the total area of permanent forest (in hectares – ha) in the monitoring period.
Activity Data of Permanent Forest Regeneration (AD_E)	$AD_{E_k} = \frac{\lvert E_k \rvert}{N} * \sum_{i=1}^{I} AD_{F-F_{i,t}}$ **Equation 2.5**	Where $\lvert E_{k,} \rvert$ is the count of sampling points where canopy change increase (dimensionless) in forest type k, *N* is the total of sampling points (dimensionless), and AD_{F-F_t} is the total area of permanent forest (in hectares – ha) in the monitoring period.
Emissions & Removals from Deforestation $E_{D\&R(AAAA-AA)}$	$E_{D\&R(AAAA-AA)} = \sum_{k=1}^{I} AD_{D_{i,t}} * EF_{D_i} + \sum_{k=1}^{I} AD_{R_{i,t}} * EF_{R_i}$ **Equation 2.6**	Where i is a land-use transition represented in a cell of the land-use change matrix (dimensionless), EF_{D_i} is the deforestation emission factor for land-use transition i, EF_{R_i} is

the removal factor for land-use transition i (when land-use transition i is forest loss, activity data and emission factor for forest recovery are cero and vice versa).

Emission & Removals from Degradation $E_{Deg(AAAA\text{-}AA)}$

$$E_{Deg(AAAA-AA)} = \sum_{i=1}^{I} AD_{Deg_k} * EF_{Deg_k} + \sum_{i=1}^{I} AD_{E_k} * EF_{E_k}$$

Equation 2.7

Where k is a forest type, EF_{Deg_k} is the degradation emission factor for forest type k, EF_{E_k} is the removal factor for forest type *k.*

Deforestation EFs were determined from C stocks. C stock changes (ΔC) were estimated using the Stock-Difference Method by applying IPCC (2006) equation 2.5 (cf. Volume 2, Chapter 2, Section 2.2.1.). All results were multiplied by the stoichiometric ratio 44/12, as follows:

$$\Delta C = \frac{(C_{t2} - C_{t1})}{(t2 - t1)} * 44/12$$ **Equation 3**

Where:

ΔC	=	C stock changes associated to the land use transition *i* in year *t*; tCO_2-e ha^{-1}
C_{t1}	=	C stock at time *t1*, t CO_2 ha^{-1} *t1* in all cases was the 1st of January of each year *t*, *i.e.* C_{t1} is the C stock per hectare existing at the beginning of the year, before the conversion occurs. The estimated values are reported in the column K of the sheets "ER AAAA" (where "AAAA" stands for the year *t*) in the FREL TOOL.
C_{t2}	=	C stock at time *t2*, t CO_2 ha^{-1} *t2* in all cases was the 31st of December of each year *t*, *i.e.* C_{t2} is the C stock per hectare existing at the end of the year, after the conversion occurred. The estimated values are reported in the lines 19[28] and 20[29] of the sheets "ER AAAA" (where "AAAA" stands for the year *t*) in the FREL TOOL.
t2-t1	=	In all cases the C stock changes were estimated annually, *i.e. t2-t1* = 1 year.
44/12	=	Conversion of C to CO_2

Forest C is determined from the NFI biomass data, converted to carbon as follows:

$$C_t = \sum_{j,i} (B_{tot}) \text{ x CF}$$ **Equation 4**

Where:

B_{tot}	=	Total biomass stock for the land use category *LU*; tCO_2-e ha^{-1}. Total biomass is equivalent to the sum of all biomass pools: $B_{tot} = B_{AGB} + B_{BGB} + B_{DW} + B_L$ Where: AGB is above-ground biomass for land use category *LU*; tCO_2-e ha^{-1} BGB is below-ground biomass for land use category *LU*; tCO_2-e ha^{-1} DW is dead wood biomass for land use category *LU*; tCO_2-e ha^{-1} L is litter biomass for land use category *LU*; tCO_2-e ha^{-1}
CF	=	Carbon fraction of dry matter in tC per ton dry matter. The value used is: **0.47** is the default for (sub)tropical forest as per IPCC AFOLU guidelines 2006, Table 4.3.

Carbon stocks of non-Forest land uses are estimated as the average values reported by the selected studies:

- *Cropland:* carbon stock values reported in selected studies showed high variability, depending on crop type (sugar cane, coffee, banana, cocoa, etc.). For this reason, the carbon stock data compiled were weighted

[28] The C stock values reported in line 19 represent total C stocks existing in secondary forest and tree plantation at the end of the first year at which they meet the definition of "Forest", i.e., 4 years for all forest strata and 8 years for dry forests. These values are used to estimate ΔC in conversions of non-Forest land use categories to Forest land and conversions of other land use categories to permanent crops.

[29] The C stock values reported in line 20 represent total C stocks existing in the land use categories at the end of the year. They are used to estimate ΔC in all land use transitions, except conversions of non-Forest land use categories to Forest land and conversion of other land use categories to permanent crops.

by the surface area of the respective crops in Costa Rica to produce a single estimate of carbon stocks from cropland.

- *Grassland:* carbon stocks were estimated as the average values reported in different carbon pools in the selected studies.
- *Settlements and (non-forested) Wetlands:* no studies could be found reporting biomass values for these categories. It was assumed that their carbon stock is zero.
- *Other Land:* studies were found reporting carbon stocks for *Paramo.* In the case of *Bare Soil* it was assumed carbon stocks are zero.

Additional details on AD, EF, and calculations in the reference level and monitoring period are available in Section 3 and Annex 4 of this monitoring report.

2.2.2.1.2 Monitored emissions ($\mathbf{GHG_t}$)

Annual gross GHG emissions over the monitoring period in the Accounting Area ($\mathrm{GHG_t}$) are estimated as the sum of annual change in total biomass carbon stocks (ΔC_{B_t}).

$$\mathrm{GHG_t} = \frac{\sum_{t}^{MP} ER_{RA_t}}{MP} = \frac{\sum_{t=1}^{MP}\sum_{i=1}^{I}\left(\mathrm{AD_{RA_{i,t}}} * \mathrm{EF_{RA_{i,t}}}\right)}{MP}$$ **Equation 5**

Where:

$\mathrm{ER_{RA_t}}$	=	Emissions or removals associated to REDD+ activity RA in year t; tCO2-e yr-1
$\mathrm{AD_{RA_{i,t}}}$	=	AD associated to REDD+ activity RA for the land use transition i in year t; ha yr-1
$\mathrm{EF_{RA_{i,t}}}$	=	EF associated to REDD+ activity RA applicable to the land use transition i in year t; tCO2-e ha-1
MP	=	Monitoring Period in years
i	=	A land use transition represented in a cell of the land use change matrix; dimensionless
I	=	Total number of land use transitions related to REDD+ activity RA; dimensionless
t	=	A year of the historical period analyzed; dimensionless

Deforestation and Reforestation Activity Data (**AD_D** and **AD_R**) are calculated differently from Degradation and Enhancement Activity Data (**AD_{Deg}** and **AD_E**). Deforestation and Reforestation ADs result from the cartographic comparison of land-use maps from the beginning and end of the monitoring period. The Degradation and Enhancement DAs result from the sample-based estimation of canopy change area in permanent forest lands. Below are the equations used to calculate these parameters:

Activity Data of Deforestation (AD_D)	$AD_{D_{i,t}} = \left\|D_{i,t}\right\| * 0.81$, **Equation 5.1**	Where $\left\|D_{i,t}\right\|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Activity Data of Reforestation (AD_R)	$AD_{R_{i,t}} = \left\|R_{i,t}\right\| * 0.81$, **Equation 5.2**	Where $\left\|R_{i,t}\right\|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Forest remaining forests ($AD_{F\text{-}F}$)	$AD_{F-F_{i,t}} = \left\|F - F_{i,t}\right\| * 0.81$, **Equation 5.3**	Where $\left\|F - F_{i,t}\right\|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Activity Data of Degradation (AD_{Deg})	$AD_{Deg_k} = \frac{\left\|Deg_k\right\|}{N} * AD_{F-F_t}$ **Equation 5.4**	Where $\left\|Deg_{i,t}\right\|$ is the count of sampling points where canopy change decrease (dimensionless) in forest type k, *N* is the total of sampling points (dimensionless), and AD_{F-F_t} is the total area of permanent forest (in hectares – ha) in the monitoring period.
Activity Data of Permanent Forest Regeneration (AD_E)	$AD_{E_k} = \frac{\left\|E_k\right\|}{N} * \sum_{i=1}^{I} AD_{F-F_{i,t}}$ **Equation 5.5**	Where $\left\|E_{k,}\right\|$ is the count of sampling points where canopy change increase (dimensionless) in forest type k, *N* is the total of sampling points (dimensionless), and AD_{F-F_t} is the total

		area of permanent forest (in hectares – ha) in the monitoring period.
Emissions & Removals from Deforestation $E_{D\&R(AAAA\text{-}AA)}$	$$E_{D\&R(AAAA-AA)} = \sum_{k=1}^{I} AD_{D_{i,t}} * EF_{D_i} + \sum_{k=1}^{I} AD_{R_{i,t}} * EF_{R_i}$$ **Equation 5.6**	Where i is a land-use transition represented in a cell of the land-use change matrix (dimensionless), EF_{D_i} is the deforestation emission factor for land-use transition i, EF_{R_i} is the removal factor for land-use transition i (when land-use transition i is forest loss, activity data and emission factor for forest recovery are cero and vice versa).
Emission & Removals from Degradation $E_{Deg(AAAA\text{-}AA)}$	$$E_{Deg(AAAA-AA)} = \sum_{i=1}^{I} AD_{Deg_k} * EF_{Deg_k} + \sum_{i=1}^{I} AD_{E_k} * EF_{E_k}$$ **Equation 5.7**	Where k is a forest type, EF_{Deg_k} is the degradation emission factor for forest type k, EF_{E_k} is the removal factor for forest type k.

Changes in total biomass carbon stocks are calculated following Equation 3 above.

3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

Table 2: Source of Activity Data and description of the methods for developing the data for estimate emissions from deforestation during the reference period[30].

Parameters:	**Activity Data of Deforestation (AD_D) Eq. 2.1** **Activity Data of Reforestation (AD_R) Eq. 2.2** **Forest remaining forests (AD_{F-F}) Eq. 2.3**
Description:	Deforestation: Hectares of forest that changed to non-forest land in a year summed each year (i) of the reference period. Reforestation: Hectares of non-forest that changed to forest land in a year, summed for each year (i) of the reference period. Forest remaining forests: Hectares of Forest remaining forests in a year, summed for each year (i) of the reference period
Data unit:	Hectares
Source of data	
Introduction	AD for land-use change activities was derived from map-algebra by analyzing all land cover maps created for 1998-2011 and estimating multi-temporal data for the areas that remained in the same category or converted to other land cover categories. Annual AD was interpolated for years in which maps were not produced. A time-series of land use maps was created for 1985/86-2012/13 in a Geographical Information System (GIS)[31] and then extracting the values of the areas that remained in the same category or converted to other land use categories from the combined set of multi-temporal data. The area covered by the land-use maps includes the country's continental territory (5,133,939.50 ha) but excludes Coco Island (238,500 ha). The land use maps were created using the methodology summarized here; further information may be found in separate reports [32,33,34] :
Data sources for estimating activity data:	The construction of the AD time series required the following sources of data: i. Remotely sensed data from four generations of the Landsat family (Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM and Landsat 8 OLI/TIRS). ii. A "Life Zones" map according to the classification system of Holdridge (1966). This map was used to stratify "Forests" into the three sub-categories: "Wet and Rain Forests", "Moist Forests" and "Dry Forests". iii. Ancillary data to edit the results of the spectral classification of remotely sensed data and to further stratify the five forest categories "Wet and Rain Forests", "Moist Forests", "Dry Forests", "Mangroves" and "Palm Forests" into the sub-categories "primary forests" and "secondary forest. iv. The Global Forest Change project (Hansen et al., 2013) has been used to fill in pixels without information in the mosaic of classifications for each year of the series between 2000 and 2012.
Methods for mapping land-use and land-use change	

[30] All AD parameters listed in table 2 sourced from the same survey.

[31] The geodatabase with the time-series of land use maps created for the reference period 1985/86-2012/13 can be accessed at the following link: https://drive.google.com/drive/folders/1XulVBwfZNam6acIksq-ZMQoK_ISqy0V2?usp=sharing

[32] Agresta, Dimap, Universidad de Costa Rica, Universidad Politécnica de Madrid. 2015. Final Report: Generating a consistent historical time series of activity data from land use change for the development of Costa Rica's REDD plus reference level: Methodological Protocol. Report prepared for the Government of Costa Rica under the Carbon Fund of the Forest Carbon Partnership (FCPF). 44 pp. https://www.dropbox.com/s/ygjw6zq00a1qtbm/Informe_tecnico_feb_2015.pdf?dl=0

[33] Ministry of the Environment and Natural Resources of Costa Rica. (2016). Modified REDD+ Forest reference emission level/forest reference level (FREL/FRL). COSTA RICA. SUBMISSION TO THE UNFCCC SECRETARIAT FOR TECHNICAL REVIEW ACCORDING TO DECISION 13/CP.19. Retrieved from https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf

[34] Ministry of the Environment and Natural Resources of Costa Rica. (2018). Costa Rica Emission Reductions Program to the FCPF Carbon Fund (Second Revision). Retrieved from https://www.forestcarbonpartnership.org/system/files/documents/Costa Rica ERPD EN_Oct24-2018_clean.pdf

Selection of images	Costa Rica prepared the FREL / FRL Costa Rica from a time series of satellite images for 1987-2013. The time series includes images from four generations of LANDSAT satellites: Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM +, Landsat 8 OLI / TIRS. The analyst downloaded the satellite information through the USGS Earth Explorer server. It was necessary to work with seven LANDSAT scenes to cover the continental territory of Costa Rica in each of the years of the series: two scenes from path 14 (rows 53 and 54), three scenes from path 15 (rows 52, 53, and 54) and two scenes from path 16 (rows 52 and 53). Low cloud-coverage Landsat images were combined to minimize the area covered by clouds and cloud shadows. In most cases, the scenes were selected from the same year and season but, in some cases, it was necessary to choose scenes from different years within a 14-month timeframe.
Pre-processing and Geometric validation	All images were registered to a standard system of coordinates (CRTM05). The mean quadratic error in control points was less than one pixel (30 m). The maximum registration error was estimated at 2 pixels (60 m). The 2005 orthophotography generated with the IDB-Cadastral project's CARTA mission has been used to collect control points for the geometric validation of the reference runs. A mosaic of scenes is prepared for each path's available dates with the geometrically corrected images.
Radiometric normalization	All images were radiometrically normalized. This process is applied to reduce radiometric differences between images due to atmospheric conditions and the sensors' calibration at image acquisition dates. The radiometric normalization was done using the "Iteratively Reweighted Multivariate Alteration Detection" (IR-MAD), as described by Canty and Nielsen (2008)[35]. The normalization of the time series used as a reference the zenith angle 36.90° corresponding to February 17, 2013.
Random Forest classification	The classification of the images uses the Random Forest (RF) method. This methodology has 2 phases: (1) training or adjustment of the RF and (2) classification of the images using the generated RF classifier. Homogeneous regions of interest have been digitized according to the land cover classes between 2011 and 2014 (see Table 3 of Agresta, 2015) for the models' adjustment. The base information used for the digitization and photointerpretation of these regions has been i) the systematic grid of cover points taken on the RapidEye images by SINAC for the elaboration of the map of forest types of Costa Rica 2013 (10,000 points distributed in the national territory), ii) the RapidEye high spatial resolution images themselves, iii) both current and historical images available on Google Earth. Control points for RF training have been randomly generated from these regions of interest. In total, 20 predictor variables (also called covariates or auxiliary variables) were used for the adjustment of the RF models, divided into four groups: (1) Spectral information of the bands, (2) Indices of vegetation, (3) Variables related to the texture of the image, and (4) Variables derived from the Digital Elevation Model. The analyst applied the classifiers to all the images according to their path and sensor. The result is a classification file for each classified image.
Postprocessing	Final maps are presented at 30 meters resolution. The preparation of the final maps from the classified images included the following tasks: i. Union of the mosaic for each date from the classified images using a pixel prioritization algorithm. The analyst merged all the different images' classifications for each of the dates and paths, eliminating the extreme strip of the paths overlapping. If the classifier predicts several classes for the same pixel, the most common category was selected, according to band 2 of the results. ii. Filling gaps with global products: The Global Forest Change project (Hansen et al., 2013) has been used to fill in pixels without information in the mosaic of classifications for each year of the series between 2000 and 2012. iii. Multi-temporal analysis: the multi-temporal analysis of the series allowed assigning the age class to each of the forest pixels, analyzing the years that have elapsed from the date of appearance of a new forest. The forest from 1987 has been considered a primary forest. Also, the multi-temporal analysis improved land-uses classification, especially when the land cover has similar spectral information. The classifier confused native forests with forest plantations. For this reason, the forest plantations were reclassified as forest. iv. Minimum mapping unit: The analyst replaced Forest Class groups of pixels smaller than 11 pixels with the LULC class of the largest neighboring group to comply with the minimum area

[35] Canty, M. J. y A. A. Nielsen, 2008. Automatic radiometric normalization of multitemporal satellite imagery with the iteratively re-weighted MAD transformation. Remote Sensing of Environment 112 (2008):1025-1036.

	threshold of the definition of "forest (1.00 ha), and setting the minimum mapping unit. Due to the pixels' dimensions in the Landsat images (30.00 m x 30.00 m), the minimum mapping area is 0.99 ha, equivalent to 11 pixels (11 x 30.00 m x 30.00 m). v. Manual editions: In order to improve land use mapping, several editions were made, largely aimed at decreasing high classification errors (for more detail please see section 4.3.3 in Ministry of the Environment and Natural Resources of Costa Rica, 2016[36]): a. "Forest Plantations" were merged with the "Forest land" category. This means that although initially classified as a separate class, @Forest Plantations@ presented a very high classification error and, for purpose of GHG estimation, it was treated as Forest land". b. For estimating the area of "Coffee Plantations", the analyst used ancillary maps from the Ministry of Agriculture (MAG), the Costa Rican Coffee Institute (ICAFE), and the Costa Rican Meteorological Institute (IMN). These maps were used to correct the classified areas for the years 2000/01, 2007/08, 2011/12, and 2013/14. For previous maps, a mask representing potential "Coffee Plantation" areas was created using the location and elevation of all areas mapped as "Coffee Plantations" considering all available sources of information (MAG, ICAFE, and IMN). c. Paramo, Mangroves and Palm forests are ecosystems restricted to particular elevation, edaphic, inundation, and salinity conditions; it is challenging for such ecosystems to exist in other locations. Therefore, these forests were re-classified using the map of Forest types (MTB), prepared by Agresta (2015). All masks representing "Mangroves", "Palm Forests" and "Paramo" have been compiled in a map of masks that will be kept in order to enable consistent map editions in future measurement and reporting. d. Areas classified as "Urban Areas" in 2013/14 were manually edited through visual interpretation of 2013 high resolution RapidEye images and creation of a mask representing "Urban Areas" in 2013/14. Pixels originally classified as "Urban Areas" outside the mask were reclassified as "Bare Soil" and conversely, pixels classified as "Bare Soil" inside this mask were reclassified as "Urban Areas". Additionally, under the assumption that "Urban Areas" never convert to other land use categories, all pixels e. A map of potential forest types was created to assign secondary forests to a forest type (Wet and Rain Forests, Moist Forests, Dry Forests, Mangroves, Palm Forests). This map will also be used in future measurements for determining the forest type of secondary forests. The map of potential forest types was created by combining the life-zones and then overlapping the map of the masks of potential areas of "Mangroves", "Palm Forests", and "Paramo".
Activity Data calculation	AD for land use change activities such as *deforestation* and *reforestation* were estimated by combining all land use maps created for 1998-2011 in a Geographical Information System (GIS) and then extracting from the combined set of multi-temporal data the values of the areas that remained in the same category or converted to other land use categories. The results of this operation are reported in land use change matrices prepared for each measurement period in the sheets “LCM 1986-91”, “LCM 1992-97”, “LCM 1998-00”, “LCM 2001-07”, “LCM 2008-11”, and “LCM 2012-13” of the spreadsheets tool “FREL TOOL CR[37]”.
Value applied in reference period:	
	1998-2011: • Total anthropogenic deforestation: 30,439 ha yr^{-1} • Primary forest anthropogenic deforestation: 13,147 ha yr^{-1} • Secondary forest and tree plantation anthropogenic deforestation: 17,292 ha yr^{-1}
QA/QC procedures applied	
Introduction	The QA/QC procedures applied during the preparation of the land-use maps used to calculate AD for the reference period are summarized here, further information may be found in Agresta (2005), Sections 3, 4, and 7:

[36] Ministry of the Environment and Natural Resources of Costa Rica. (2016). Modified REDD+ Forest reference emission level/forest reference level (FREL/FRL). COSTA RICA. SUBMISSION TO THE UNFCCC SECRETARIAT FOR TECHNICAL REVIEW ACCORDING TO DECISION 13/CP.19. Retrieved from https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf

[37] The FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing

Download and satellite image preparation	1. Verification of file storage errors in digital media that could affect reading the data by the analyst responsible for download support images. 2. Previewing and verification of the satellite image quality and metadata by the analyst responsible for downloading support images. 3. Previewing and verification of the satellite image quality and metadata by the supervisor.
Image orthorectification	1. Analyst's exhaustive visual inspection to identify errors in the orthorectification process, such as duplicated areas, pixel stretching, or geometric errors related to the digital terrain model (DTM). 2. Geometric control of orthorectified images by taking checkpoints in each scene in a regularly distributed grid. 3. Validation of root mean square error (RMSE) of the control points, by the analyst responsible for the orthorectification. In no case, RMSE is above the pixel size of the image. The number of correct points after debugging should not be less than 20 ground control points in each reference path. The RMSE obtained in the checkpoints is less than 1 pixel (30 meters), and the maximum error in any of the points, 2 pixels (60 meters). 4. Preparation of a "georeferencing validation datasheet," including a general image view with the checkpoints marked on it and a list of the coordinates and RMS obtained for each point. Annex 5 of Agresta (2015) includes the lists of checkpoints and RMSE of the dates processed.
Radiometric normalization*:*	5. Radiometric normalization to reduce the differences between the time-series images.
Generation of cloud and shadow masks	6. Validation of cloud and shadow mask by visual verification of a systematic random grid of checkpoints identified as a cloud (n), shadow (s), or clear (d). The analyst visually checked the original image in RGB or false color if the classification matches the cloud and shadow mask. The analyst must pay special attention to the verification of cloud masks in urban areas and coastlines with a high reflectance, adjusting some of the cloud and shadow mask degeneration parameters during the verification process. 7. The validation includes a random sample in each path of an image from each time series (3 paths x 6 series = 18 images). Table 2 of Agresta (2015) includes a summary of the results of the validation of the cloud and shadow maps.
Land use classification*:*	8. Analysts perform an iterative process of classification, verification of results, error detection, and review of areas and training points. 9. Progressive improvement of the areas and training points of the RF classifier before the final classification of the images. Review of the Random Forest classifiers' errors, identify classes that need improvement, and training points. 10. Visual verification and validation of classified images by comparing them with the available high-resolution image.
Preparation of land-use maps:	11. Visual check of mosaics and identify information gaps and sensor failures on each time series' images. 12. Visual verification of the maps generated after filling the gaps with global data. 13. Analysts implement an independent validation of the land-use change maps with ground validation points provided by the country's institutions not used in the classification phase. 14. Manual edition of the time-series classification to improve land use mapping, largely aimed at decreasing high classification errors.
Visual verification and validation of land-use change map:	15. Visual verification of the country's main deforestation and reforestation areas between consecutive years of the series to detect classification errors. 16. Validation of land-use changes between 2001 and 2011 based on photointerpretation of changes on a systematic random grid of points and using the Landsat, aerial orthophotography of the year 2005, and Rapid-eye images of the years 2011 and 2012.
Uncertainty associated with this parameter:	
Uncertainty associated with this parameter:	Uncertainties associated to AD are due to the production process of land use maps. The uncertainties of the AD for land use change activities (deforestation and reforestation) and forest remaining forest activities (degradation and enhancements in forest lands) come from the uncertainties (i.e. the margin of error for a 90% confidence level divided by the estimate) associated with the process creating land use change maps from which the activity data are obtained. The accuracy assessment of the land-use change map 2001/02 – 2011/12 was done

	following Olofsson et al.'s (2014)[38] guidelines. Due to a large number of land-use change transitions, they were aggregated into four categories: Deforestation (forest to non-forest), new forests (non-forest to forest), stable forest (forest remaining forest), and stable non-forest (non-forest to non-forest). The validation of land-use changes during the period 2000/2001 - 2010/2011 is based on the photointerpretation of orthophotography from 2005, Rapid eye imagery, and Landsat images, since they have higher quality and spatial resolution than the maps and are independent of the sample of land-use data used to produce the maps. For further detail please see section 12.2 in ERPD document (Ministry of the Environment and Natural Resources of Costa Rica, 2018)[39]. Finally, 699 checkpoints were assessed: 315 in stable forest areas (areas classified as forest in 2000/01 remaining forest in 2010/11), 237 in the non-stable forest (areas classified as non-forest in 2000/01 remaining non-forest in 2010/11), 53 in afforestation/reforestation areas (areas classified as non-forest in 2000/01 classified as forest in 2010/11) and 47 in deforested areas (areas classified as forest in 2000/01 classified as non-forest in 2010/11)[40]. The accuracy assessment analysis is presented in the Excel file "CDI_CostaRicaREL_AnalisisExactitud_MCS2000-2001 vs MCS2010-2011" [41]. The activity data's uncertainty is the bias between the adjusted (reference data) and estimated (land use maps) areas. The uncertainty values are as follows (see cells F56-F59 of spreadsheet "2.4E Datos Actividad 2001-2011 in excel file CDI_CostaRicaREL_AnalisisExactitud_MCS2000-2001 vs MCS2010-2011): Uncertainty of hectares of deforestation from 1998-2011: 26% Uncertainty of hectares of non-forest that changed to forest land: 51% Uncertainty of hectares of forests remaining forests in 1998-2011: 7%

Table 3: Source of Activity Data and description of the methods for developing the data for estimate emission from degradation during the reference period.

Parameters:	**Activity Data of Degradation (AD_{Deg}) Eq. 2.4** **Activity Data of Permanent Forest Regeneration (AD_E) Eq. 2.5**
Description:	Degradation: Hectares of forest with a reduction of canopy cover during the reference period. Forest Enhancement: Hectares of forest with an increase of canopy cover during the reference period
Data unit:	Hectares
Source of data	
Introduction	The forest degradation assessment was made on forest lands that remain as forest lands. The analysis of degradation was only performed on the area of forest remaining forest according to the land-use MCS 2012/13 map to avoid double-counting of baseline emissions between deforestation and forest degradation. This procedure avoided any measurements of degradation that were also accounted for under deforestation. Reference data to estimate Degradation AD were collected by Ortiz-Malavassi, (2017)[42].
Type of sampling	A Systematic Sampling (SYS) over the Level 1 Systematic Grid of 10,242 points of the Monitoring system of land-use change and ecosystems (SIMOCUTE) was used. The original systematic grid is in the CRTM05 coordinate system of Costa Rica. However, it was re-projected to geographic coordinates in WGS84 to evaluate the sampling point with the Collect Earth Desktop tool. The

[38] Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148, 42-57.
[39] Ministry of the Environment and Natural Resources of Costa Rica. (2018). Costa Rica Emission Reductions Program to the FCPF Carbon Fund (Second Revision). Retrieved from https://www.forestcarbonpartnership.org/system/files/documents/Costa Rica ERPD EN_Oct24-2018_clean.pdf
[40] Shape file with 716 checkpoints included in the accuracy assessment analysis can be accessed in the following link: https://drive.google.com/drive/folders/1ofSZs-IfdZ-BzFxefqrGO1pwbp537HL1?usp=sharing
[41] Accuracy Assessment 2001-2011 analysis can be accessed in the following link (CDI_CostaRicaREL_AnalisisExactitud_MCS2000-2001 vs MCS2010-2011.xlsm excel file): https://drive.google.com/file/d/1wUfwkW4E74Y-AZHCesr4coNIs0e_SabC/view?usp=sharing
[42] Ortiz-Malavassi, E. (2017). Evaluación Visual Multitemporal (EVM) del Uso de la tierra, Cambio en el Uso de la Tierra y Cobertura en Costa Rica Zonas A y B Tarea 1: Estimación del área de cambio de uso de la tierra durante el periodo 2014-2015. Retrieved from https://drive.google.com/file/d/1GXdN43f-DNKelkM8y7gBLrKou-f7LI-G/view?usp=sharing

	SIMOCUTE sampling units are permanent, which facilitates reinterpretation through time and easy temporal tracking of LULC changes.
Sampling Unit	The Sampling Unit (SU) is a 90x90 meter plot whose central point coincides with the SIMOCUTE sampling points. The SU corresponds to 3x3 Landsat pixels and covers 0.98 ha. Inside SU, a 7x7 points sub-grid was created to estimate land cover percentage within each sampling unit.
Number of Sampling Units	The forest degradation assessment was made on forest lands that remain as forest lands during 1998-2016. A total of 4377 points were classified as permanent forest land according to the MCS 2012/13 map. These points are an extract from the Systematic Grid adopted in SIMOCUTE.
Classification scheme	Three classes of canopy cover were considered to estimate degradation/enhancement in permanent forest land: i. Intact forest (85-100% forest cover), ii. Degraded forest (60-85% forest cover), and iii. Very degraded forest (<60% forest cover). The following forest cover change classes were assessed by forest type and type of carbon fluxes (anthropogenic and natural): Degradation: a. Intact to Degraded forest b. Intact to Very degraded forest c. Degraded to Very degraded forest Forest enhancement: d. Very degraded to intact forest e. Very degraded to degraded forest f. Degraded to Intact forest No Condition changes g. Stable intact forest h. Stable degraded forest i. Stable very degraded forest
Imagery Sources	The range of dates of the images presented in the table below was used. Priority was given to operating with the ortho-rectified photographs of the TERRA 1997 project to evaluate the canopy cover in 1998. Still, since TERRA 1997 covered less than 40% of the national territory, the second priority was to use high-resolution images in Google Earth before 2006. If these did not exist, the next priority was to use the ortho-rectified photos of the project Carta-2005 available on the SNIT server. For the other years, the repository of high-resolution images available in Google Earth and Earth Engine was used as a data source, giving priority to images from the years to be evaluated (2011 or 2016). However, in case of absence, the use was recorded in the year closest to monitoring dates. Data sources and imagery date range used in the canopy cover evaluation on permanent forest for the reference period 1998-2011 are the following: (see table below)
Interpretation Key	The land cover class keys used to determine canopy cover for the years 1998, 2011, and 2016 are the following: (see table below)

Monitoring Year	Imagery date range	Data sources
1998	January 1997 – December 2005	• Orthophotos TERRA 1997. • Google Earth imagery repository • Mission CARTA 2005
2011	July 2011 – June 2012	• Google Earth imagery repository
2016	July 2015 – June 2016	• Google Earth imagery repository

Code	Land cover class
1100	Trees
1200	Shrubs
1300	Herbaceous
1400	Palm
1500	Bromeliads
1600	Greenhouse

	| 1700 | Other vegetation | | 2000 | No vegetation | | 3000 | Water | | 4000 | Clouds and shadows | | 5000 | Not classifiable |
Data collection	See QA/QC procedures.
Data analysis	The country developed a tool for calculating emissions and removals on permanent forest lands (¨Herramienta_degradación.xlsx¨ [43]). The database for the visual interpretation of canopy cover for the reference period 1998-2011 and period 2012-2016 are included in the sheet "Base_de_datos". The area of degraded and enhanced forest areas was extrapolated to the forest area in the entire country through proportional representation within the respective degradation classes (intact, degraded and very degraded) and forestry type. Degradation classes were determined based on the reduction of the forest canopy cover, by which intact forests have a cover of 85-100%, degraded forests have a cover of 60-85%, and very degraded forests a cover between 30% and 59%. Forest areas that went from intact to degraded, intact to very degraded, or degraded to very degraded (in terms of their canopy cover) during the assessment period (1998-2011) were classified as degraded. Forest areas that went from very degraded to degraded, very degraded to intact, or degraded to intact were identified as forest enhancement areas. Carbon fluxes were estimated for anthropogenic and natural conditions. Fluxes from sampling points inside protected areas and farther than 500 meters from a road[44] were considered natural fluxes and removed from reference level accounting. The estimation of the areas of change of degradation and canopy enhancement, for both anthropic and natural carbon fluxes, can be found in the sheet ¨Resumen_de_puntos¨ of the Degradation tool, for the reference period 1998-2011 and period 2012-2016.
Value applied in reference period:	
	• **2,233,119** hectares of forests remaining forests in the reference period (1998-2011) • **145,556** hectares of anthropogenic degradation (1998-2011) • **157,739** hectares of anthropogenic forest enhancement (1998-2011)
QA/QC procedures applied	
	Ortiz-Malavassi (2017) prepared a land cover evaluation protocol to reduce the uncertainty of the land cover classification due to: a) the bias associated with the spatial registration of the reference image, b) the interpreter bias in the assignment of the land cover class; and c) interpreter variability. The protocol includes the operational definition of the canopy coverage with examples taken from high-resolution images and registration templates for Collect Earth Desktop. The following procedures were applied during the collection of reference data: **Data registry forms**: The canopy cover change information was recorded in standard Collect Earth Desktop forms. **Variability between interpreters**: The analysts recorded screenshots, plot numbers, and a brief description of the problem in case of doubts with the interpretation (land cover and land-use). Every two days, they sent the log to other analysts for feedback. This feedback was available to all team members. Meetings will be held at the end of the week to discuss complex cases to reduce interpreters' variability. **Validation of the coverage classification**: The supervisor validated land cover classification with National Forest Inventory land cover data. This information was available only for the supervisors. **Imagery co-registration:** Google Earth images can show displacements, which became evident when the interpreter compares the same area for different years. Potere (2008)[45] found that the average displacement in developing countries is 44.4 meters. When this problem occurred, the analyst noted the maximum displacement detected in meters in Collect Earth form.

[43] Degradation tool can be accessed in the following link: https://drive.google.com/file/d/1GG3Z_QMWBKGNRdXnF_TdWP1ipH9dX5iH/view?usp=sharing

[44] The latest and highest-resolution official roads map for Costa Rica was used for this exercise, which was completed in 2007. It is accessible via the National System of Territorial Information (SNIT) website: http://www.snitcr.go.cr/Metadatos/full_metadata?k=Y2FwYW1ldGFkYXRvczo6Y2FwYTo6SUdOXzU6OnZpYXNfNTAwMA

[45] Potere, D. (2008). Horizontal positional accuracy of Google Earth`s high-resolution imagery archive. In: Sensors, 8,12: 7973-7981 p. Retrieved from: http://www.mdpi.com/1424-8220/8/12/7973/htm

	Data consistency: The supervisor reviewed the existence of discrepancies between cover class and land use.
Uncertainty associated with this parameter:	
	In the assessment of degradation level in forests remaining forests, it was assumed that there was no uncertainty associated with the visual interpretation of sample areas because this procedure employed visual classification of canopy cover using high resolution imagery. Uncertainty of changes in canopy cover to identify areas of degradation and forest enhancement from 1998-2011 vary depending on the forest type and the conversion class. It is based on the sampling error.

Table 4: Source of Emission Factors and description of the methods for developing the emission factors for deforestation.

Parameters:	**Carbon density of aboveground tree or woody biomass (C_{AGB}) Eq. 4** **Carbon density of belowground biomass (C_{BGB}). Eq. 4.** **Carbon density of dead wood biomass** (C_{DWB})**. Eq. 4** **Carbon density of litter (C_L). Eq. 4**
Description:	• **C_{AGB}**: Amount of carbon (C) contained in aboveground biomass per forest hectare, converted to CO_2e multiplying by a factor of 44/12 (i.e., the molecular weight of a CO_2 molecule over the molecular weight of a C molecule). • **C_{BGB}**: Amount of C contained in belowground forest biomass per forest hectare, converted to CO_2e multiplying by a factor of 3.67 (i.e., the molecular weight of a CO_2 molecule over the molecular weight of a C molecule). • **C_{DWB}**: Amount of C contained in dead wood forest biomass (standing and lying) per forest hectare, converted to CO_2e multiplying by a factor of 3.67 (i.e., the molecular weight of a CO_2 molecule over the molecular weight of a C molecule). • **C_L**: Amount of CO_2e contained in litter forest biomass per forest hectare.
Data unit:	Tonnes of CO_{2e} per hectare
Source of Data	
Introduction	The emission factor for deforestation of primary forest is derived from data collected during Costa Rica's first National Forest Inventory (INF-CR for its acronym in Spanish), and models or average values of direct measurements reported in literature. • **Carbon pool of aboveground tree or woody biomass (C_{AGB}):** Carbon pool of aboveground tree or woody biomass for each Primary Forest type (C_{AGB}) is the area-weighted average of C_{AGB} stock value from 2015 field campaign performed for the National Forest Inventory. • **Carbon pool of belowground biomass (**C_{BGB}**)**: Derived directly from C_{AGB} data following the Cairns et al., (1997) formula. • **Carbon pool of dead wood biomass (C_{DWB})**: Average values of direct measurements reported in literature. The value was used to develop a ratio of C_{DWB} over C_{AGB} used for AD_D, AD_{F-F}, and AD_R. The values obtained from the literature were used to develop an area-weighted average of DW:AGB ratios, assumed to be the same in primary and secondary forests. • **Carbon pool of litter (C_L):** Average values of direct measurements reported in literature. The value was used to develop a ratio of C_L over C_{AGB} used for AD_D, AD_{F-F}, and AD_R. The values obtained from the literature were used to develop an area-weighted average of L:AGB ratios, assumed to be the same in primary and secondary forests.
Source of Data of Above Ground Biomass for Primary Forest	**Type of sampling:** The INF-CR is a multipurpose inventory seeking to enhance the understating of Costa Rican forest resources and generate data to monitor and quantify their provision of ecosystem services, such as climate change mitigation. The INF-CR was led by the National Conservation Area System (SINAC) with measurements taken between 2013 and 2015. The INF-CR employed a stratified-systematic sampling approach covering the entirety of Costa Rica's continental territory. The stratification was based on a forest type map derived from RapidEye

	imagery (REDD/CCAD-GIZ-SINAC, 2015)[46] and plots were equidistantly allocated within each stratum. **Sampling Unit:** Rectangularly shaped plots with an area of 0.1 ha (20m x 50m) distributed on fixed sample intensities by forest class. The sampling unit design allows the measurements of the following (Ministerio de Ambiente y Energía, 2015)[47]: • Primary Sampling Unit (UMP for its acronym in Spanish) for measurement of live tree DBH and height of trees with DBH ≥ 10cm (light green area) • Secondary Sampling Unit (UMS for its acronym in Spanish) for measurement of saplings with 2cm ≤DBH<10cm, and height >1.5m. • Third-order Sampling Unit (UMT for its acronym in Spanish) for measurement of live non-tree vegetation, including seedlings (DBH<2cm and height<1.5m), were taken (light grey circles) • Fourth-order Sampling Unit (UMC for its acronym in Spanish) to measure the abundance of species. • Fifth-order Sampling Unit (UMH) to measure litter. • Lying deadwood sampling (UMM) to measure the lying deadwood's diameter in the 20m transects. Soil sampling of the first 30cm with cylinder method. **Number of Sampling Units:** The INF-CR installed a total of 286 single plots. Out of the 286 sampling units (SU), litter was sampled only in 54, and lying deadwood in 61 SUs. Because of inconsistent sampling of all carbon pools across all plots and lack of confidence in data where litter and deadwood, a decision to consider only aboveground biomass from INF-CR was made. Some SU presented zero as a result of litter and deadwood pools. It was not verified whether the SU represented the absence of litter and deadwood in the plots, or these carbon pools weren't sampled.
Source of Data of Above Ground Biomass for Secondary Forest	The AGB for secondary forest was estimated assuming the forest stand accumulated biomass since its restoration. The AGB of Wet and Rain Forests, Moist Forests and Dry Forests were estimated using the equations developed by Cifuentes (2008)[48] based on direct measurements in 54 plots located in age classes between 0 and 82 years. For Mangroves and Palm Forests, a linear function was assumed for estimating carbon stocks as a function of age. Wet and Rain Forests (Cifuentes, 2008, Table 2.5, p. 42, equation for "*Tropical Wet*"): $$TAGB_t = B_{max} * \left[1 - e^{(-0.0186*t)}\right]^1$$ Moist Forests (Cifuentes, 2008,, Table 2.5, p. 42, equation for "*Tropical Premontane Wet Transition to Basal-Atlantic*"): $$TAGB_t = B_{max} * \left[1 - e^{(-0.0348*t)}\right]^1$$ Dry Forests (Cifuentes, 2008,, Table 2.5, p. 42, equation for "*Tropical Dry*"): $$TAGB_t = B_{max} * \left[1 - e^{(-0.113*t)}\right]^{5.1411}$$ Mangroves and Palm Forest the following linear equation was applied: $TAGB_t = \frac{B_{max}}{100} * t$, when *t* <= 100 $TAGB_t = B_{max}$, when *t* > 100 It was assumed that the maximum biomass in secondary forests (B_{max}) equals the biomass estimated for primary forests.
Source of data of Litter and Deadwood in primary and secondary forest	The carbon stocks of litter and deadwood were estimated based on a compilation of values from published literature. All C stock estimates from the consulted sources were compiled in tons of carbon per hectare (tC ha-1), using IPCC's default carbon fraction (0.47) when the values were reported in tons of dry matter (t d.m. ha^{-1}). All information related to C stock estimates, such as information on land use, number of sampling units, plot size, the allometric equation used, etc.,

[46] Sistema Nacional de Áreas de Conservación (SINAC) - Programa REDD-CCAD-GIZ. (2015). Cartografía base para el Inventario Forestal Nacional de Costa Rica 2013-2014. Retrieved from https://www.sirefor.go.cr/pdfs/Documento-cartografia-Imprenta.pdf

[47] Ministerio de Ambiente y Energía. (2015). Volumen 4 Marco conceptual y metodológico para la Inventario forestal nacional de Costa Rica. Retrieved from https://www.sirefor.go.cr/pdfs/Volumen4-MarcoC-Imprenta.pdf

[48] Cifuentes, M. (2008). Aboveground Biomass and Ecosystem Carbon stocks in Tropical Secondary Forests Growing in Six Life Zones of Costa Rica (Oregon State University). Retrieved from https://drive.google.com/file/d/1FsiTVc78EHcU0gQ4JfFJFSlPqesm3JFW/view?usp=sharing

	were also recorded. For full detail please check BaseDeDatos_v5[49] and C-STOCKS sheet of FREL TOOL[50]. The literature review employed the following criteria for compiling the reported value: • The publication reported data from direct measurements carried out in Costa Rica • Measurements were carried out after the year 2005 • Data were sufficiently disaggregated by reporting values of carbon stocks per land use categories and per carbon pool sampled • The publications included information on uncertainties related to the carbon stock estimates
Source of data of carbon stocks of non-Forest land uses	C stocks in these non-forest land uses were estimated as the average values reported by the selected studies. For full detail please check BaseDeDatos_v5 and C-STOCKS sheet of FREL TOOL. • **Cropland**: carbon stock values reported in selected studies showed high variability, depending on crop type (sugar cane, coffee, banana, cocoa, etc.). For this reason, the carbon stock data compiled were weighted by the surface area of the respective crops in Costa Rica to produce a single estimate of carbon stocks from cropland. • **Grassland:** carbon stocks were estimated as the average values reported in different carbon pools in the selected studies. • **Settlements and (non-forested) Wetlands:** no studies could be found reporting biomass values for these categories. It was assumed that their carbon stock is zero. • **Other Land:** studies were found reporting carbon stocks for *Paramo.* In the case of *Bare Soil,* it was assumed carbon stocks are zero.
Methods for estimating C stocks and Emission Factors	
	• **Above ground biomass (AGB)**: Above ground of forest biomass is calculated as 47% of the biomass dry weight of standing trees in the forest, which is calculated using allometric equations. Aboveground biomass of each measured tree was estimated using Chave et al., (2005)[51] moist forests allometric equation as follows: $AGB = \exp\left(-2.977 + \ln\left(\rho * DBH^2 * HT\right)\right)$ *Where:* *AGB: aboveground biomass (kg)* *ρ: wood specific gravity (g/cm³). Obtained from literature.* *DBH: Diameter at breast height (cm)* *HT: Tree height (cm)* AGB estimates at the tree level are then summed per plot, and extrapolated to a per hectare basis by applying a scaling factor of 10, which represents the proportion of a hectare (10,000 m²) that is occupied by the plot as follows: $ScalingFactor = \frac{10{,}000m^2}{1{,}000m^2} = 10$ *Where:* *10,000m²: Area of one hectare (m²)* *1,000m²: Area of INF-CR rectangular plot (20m x 50m)* • **Below ground biomass (BGB)**: BGB is derived directly from Cairns et al., (1997).[52] equation, to estimate C_{BGB} from C_{AGB} data: $\mathrm{BGB} = \exp\left(-1.085 + 0.9256 * \ln\left(\mathrm{AGB}\right)\right)$ Where: BGB: belowground biomass (t d.m. ha^{-1}) AGB: aboveground biomass (t d.m. ha^{-1}) This equation was applied to both, primary and secondary forests. • **C stocks of forest** lands corresponds to the area-weighted average of C stocks by C pool and strata. • **C stock changes** (ΔC) are estimated using the Stock-Difference Method by applying IPCC (2006) equation 2.5 (cf. Volume 2, Chapter 2, Section 2.2.1.).

[49] BaseDeDatos_v5.xlsx can be accessed at the following link: https://drive.google.com/file/d/1d6QqYQci7_Qo7DJhS5eOKgCqLFDX-rFX/view?usp=sharing

[50] The FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing

[51] Chave J et al. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145: pp. 87-99.

[52] Cairns M.A., Brown S., Helmer E.H., and Baumgardner G.A. (1997). Root biomass allocation in the world's upland forests. Oecologia 111:1-11.

Value applied in reference period:

Carbon stocks in Primary forest

Primary Forest type	Area-weighted average		
	t C_{AGB} ha^{-1}	t C_{DWB} ha^{-1}	t C_{L} ha^{-1}
Wet and Rain Forests	131	13.5	2.7
Moist Forests	93	13.2	2.2
Dry Forests	62	15.4	6.2
Mangroves	72	1.9	0.3
Palm Forests	52	1.6	0.3

Carbon stocks in Secondary Forest

The table below shows the Bmax values used in the equations above to calculate $TAGB_t$ from the secondary forest stand age.

Secondary Forest Type	B_{max} (t dry mass ha^{-1})
Wet and Rain Forests	445
Moist Forests	262
Dry Forests	155

Carbon stocks of non-Forest land uses

Non-forest land uses	Area-weighted average t C_{AGB} ha^{-1}
Permanent crop, wooded, cropland	16
Annual crop, wooded, cropland	0
Permanent crop, non-wooded, cropland	7
Annual crop, non-wooded, cropland	23
Grasslands, wooded	8
Grasslands, non-wooded	4
Paramos	35

QA/QC procedures applied

AGB in primary forest

SINAC implemented the following QA/QC procedures during the National Forest Inventory of Costa Rica (for further details please see Ministerio de Ambiente y Energía, 2015)[53]:

Fieldwork organization: SINAC organized the fieldwork by regions: North Pacific and Central Valley (PN-VC), Central Pacific and South Pacific (PS), North-Caribbean North Zone (ZN-CN), Central-South Caribbean (CC-CS), and complex sites (Talamanca mountain range). SINAC prepared terms of reference, describing each member of the field crew's roles and responsibilities. An experienced dendrologist was part of the work team, and a field manual was prepared for identifying, collecting, transport, and processing botanical samples. The Crew was trained before the start of fieldwork, and an Excel template was designed for data typing.

Fieldwork supervision: During the NFI implementation, the coordinator made field visits to supervise the crews' work. A photographic registry of each plot was made.

Registry of information: The field crew filed field forms and prepared reports of the activities. The crew chief and fieldwork director reviewed the field forms. The IFN steering committee did the final review. If the supervisor detected errors, omissions, or inconsistencies, the records were returned to the crew leader with observations for their correction or documenting the discrepancies; the dendrological inventory component coordinator reviewed questionable species identifications. Control procedures were applied to evaluate the coherence, integrity, and completeness of dasometric, dendrological, and positioning data.

[53] Ministerio de Ambiente y Energía. (2015). Volumen 4 Marco conceptual y metodológico para la Inventario forestal nacional de Costa Rica. Retrieved from https://www.sirefor.go.cr/pdfs/Volumen4-MarcoC-Imprenta.pdf

	Independent evaluation of forest inventory data quality: A separate crew evaluated the quality of forest inventory data. The independent team made field visits and re-measures 10% of the plots established by stratum, both in the pre-sampling and inventory phase.
Uncertainty associated with this parameter:	AGB's uncertainty in primary forests is derived from NFI sampling errors. Since belowground biomass is a function of aboveground biomass, the belowground biomass values have the same level of uncertainty as the aboveground biomass. Uncertainty from values DWB and L is derived from values identified in the scientific literature. The statistical uncertainty reported in these documents takes into consideration the sampling error. Therefore, the current version of the reference level only considers this error source.

Primary Forest type	Uncertainty (%) of aboveground biomass
Wet and Rain Forests	150%
Moist Forests	152%
Dry Forests	152%
Mangroves	93%
Palm Forests	81%

Non-forest land uses	Area-weighted average t C_{AGB} ha^{-1}
Permanent crop, wooded, cropland	71%
Annual crop, wooded, cropland	0%
Permanent crop, non-wooded, cropland	68%
Annual crop, non-wooded, cropland	12%
Grasslands, wooded	0%
Grasslands, non-wooded	0%
Paramos	2%

Table 5: Source of Emission Factors and description of the methods for developing the emission factors for forest degradation.

Parameters:	**Ratio AGB:Percent of canopy cover per forest type (R_C)**
Description:	• **Canopy cover and biomass relationship (R_C)**: For each forest type, a ratio was estimated of aboveground biomass (in t CO_2e) to percent canopy cover based on direct measurements in 100 permanent forest plots. These ratios were used to estimate degradation and forest regeneration in forests remaining forests.
Data unit:	Tonnes CO_2e ha^{-1} / % canopy cover
Source of Data	
Introduction	Costa Rica has updated the forest reference level by recalculating the forest degradation emissions. Additional temporal sampling plots were measured following the methodology used in the NFI to determine aboveground biomass. The number of field observations increased in 100 temporary degradation plots covering all forest types (i.e., wet and rain forests, moist forests, dry forests, mangroves, and palm forests). These new data were integrated into aboveground biomass vs. canopy cover models to develop new degradation emission factors. Degradation categories in the aboveground biomass vs. canopy cover models were updated as follows: intact forests have a cover of 85-100%, degraded forests have a canopy cover of 60-85%, and very degraded forests of 30-59%. Forest areas that went from intact to degraded, intact to very degraded, or degraded to very degraded (in terms of their canopy cover) during the reference period (1998-2011) were classified as degraded. In contrast, primary forest areas that went from very degraded to degraded, very degraded to intact, or degraded to intact were identified as forest enhancement areas.
Sampling Unit	As Sampling Unit, the Primary Sampling Unit (UMP) of the National Forest Inventory was used to generate complementary and comparable data of Aboveground biomass. The UMP has an area of 1000 m^2 on a rectangular plot of 20 x 50 meters.
Selection of Sampling Units	Rodriguez (2018)[54] and Coto (2018)[55] selected the points to visit for the assembly of the 100 temporary plots distributed by categories of canopy cover and forest type, using as input the canopy cover assessment over level 1 systematic grid of SIMOCUTE, generated by Ortiz-Malavassi (2017). It was considering that the changes in the canopy cover, can be classified into four types of degradation: 1. Degradation at the edge of the forest, 2. Degradation by elimination of isolated trees, 3. Degradation by elimination of trees in forest blocks, and 4. Degradation by eliminating trees in protection zones; Rodriguez and Coto avoided selecting sample points at sites with degradation at forest edges (types 1 and 4). Likewise, it was requested that the location of the plot reflect the corresponding canopy cover category. The following classes were identified in the first plot distribution exercise without sufficient sampling points: Dry Forest 20-40%, Mangrove 20-49% and 50-80%, and Palm forest 20-49% and 50-80%. Rodriguez and Coto used the level 2 systematic grid of SIMOCUTE to complete the plots' sample in these categories.
Number of Sampling Units	In total, 100 temporary plots were measured. Fifteen sampling plots were installed in Palm forests, 36 in Wet and Rain forests, 15 in Moist forests, 19 in Dry forests, and 15 in Mangroves. In total, 4,340 trees greater than 10 cm DBH were measured. The distribution of the 100 plots, according to the type of forest and canopy cover, is as follows:

Forest Type	Canopy cover class	

[54] Rodríguez, J. (2018). INFORME FINAL DE CONSULTORÍA Estudio de parcelas temporales para estimar el stock de carbono en bosques intactos, degradados y altamente degradados en zona A. (Contrato N°020-2018-REDD). Retrieved from https://drive.google.com/file/d/1dSyL8Dldwym5VN1jXpnAbmPovUW3AiTu/view?usp=sharing

[55] Coto, O. (2018). INFORME FINAL DE CONSULTORÍA. Estudio de parcelas temporales para estimar el stock de carbono en bosques intactos, degradados y altamente degradados en zona B. (Contrato N°019-2018-REDD). Retrieved from https://drive.google.com/file/d/1svYPJGEoBHpLn72sg4ejpf6uZkp6lllM/view?usp=sharing

	<table><tr><td></td><td>20-49%</td><td>50-79%</td><td>80-99%</td><td>Total of SU – forest type</td></tr><tr><td>*Wet and Rain Forests*</td><td>5</td><td>5</td><td>5</td><td>15</td></tr><tr><td>*Moist Forests*</td><td>12</td><td>14</td><td>10</td><td>36</td></tr><tr><td>*Dry Forests*</td><td>8</td><td>6</td><td>5</td><td>19</td></tr><tr><td>*Mangroves*</td><td>5</td><td>5</td><td>5</td><td>15</td></tr><tr><td>*Palm Forests*</td><td>5</td><td>5</td><td>5</td><td>15</td></tr><tr><td>*Total SU-canopy cover class*</td><td>35</td><td>35</td><td>30</td><td>100</td></tr></table>
Data collection	All trees, shrubs, palms, tree ferns, lianas, and vines with a Diameter at Breast High (DBH) > 10 cm were measured following the protocols of the National Forest Inventory (Ministerio de Ambiente y Recursos Naturales, 2017). The following data were collected: **Scientific Name**: registry of the genus and species of each inventoried tree. Lianas and vines were identified at the level of life form, and no samples were collected. **Species Code:** National Forest Inventory code of the scientific name (genus and species). **Diameter**: registry of diameter in centimeters and at breast height (1.3 m). **Total height**: registry of estimated total height for trees, shrubs, and palms; in the case of vines and lianas, it is not assessed. The crew member who estimated the heights performed periodic calibrations using the clinometer. **Specific Gravity**: the GE values were obtained directly from the Biomass estimation tool developed by SINAC and specialized publications (IPCC, 2003[56]; Myers, 2013[57]; Tree Functional Attributes and Ecological Database, 2018[58]).
Data analysis	The biomass and carbon content were calculated with the equation of Chave et al. (2014) with the variables DBH, total height and Specific Gravity (GE) of each individual. An Excel sheet was prepared with the database and the estimated AGB/canopy cover ratio for forest type (Calculo_FE_041220.xlsx[59]). The AGB / canopy ratio was estimated, excluding outliers. Cook's Distance statistical approach (calculated in R) was used to identify the outliers. Two points out of the total number of observations were eliminated in BMHP and BS, whereas only one outlier was identified in BH, M, and P.
Value applied in reference period	
Ratio AGB:Percent of canopy cover per forest type (R_C)	<table><tr><td>**Forest type**</td><td>**R_c - Ratio Aboveground biomass (t CO_2e ha^{-1})/ % canopy cover**</td></tr><tr><td>*Wet and Rain Forests*</td><td>5.03</td></tr><tr><td>*Moist Forests*</td><td>3.86</td></tr><tr><td>*Dry Forests*</td><td>3.47</td></tr><tr><td>*Mangroves*</td><td>3.19</td></tr><tr><td>*Palm Forests*</td><td>4.26</td></tr></table>
QA/QC procedures applied	
	The REDD+ Secretariat of Costa Rica implemented the following QA/QC procedures during the measurement of the 100 temporary plots (for further details please see Rodriguez, 2018, Coto, 2018 and Obando, 2019):

[56] IPCC. 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry. Intergovernmental Panel on Climate Change (IPCC). Edited by Jim Penman, J.; Gytarsky, M.; Hiraishi, T.; Krug, T.; Kruger, D.; Pipatti, R.; Buendia, L.; Miwa, K.; Ngara, T.; Tanabe K.; Wagner, F. IPCC National Greenhouse Gas Inventories Programme. Published by the Institute for Global Environmental Strategies (IGES) for the IPCC. 583 p.
[57] Myers, R. 2013. Fenología y crecimiento de Raphia taedigera (Arecaceae) en humedales del noreste de Costa Rica. En:Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744) Vol. 61 (Suppl. 1): 35-45
[58] Tree Functional Attributes and Ecological Database. (2018). Wood Density. Recuperado el 10 de 12 de 2018, de http://db.worldagroforestry.org/.
[59] Calculo_FE_041220.xlsx can be accessed in the following link: https://drive.google.com/file/d/1bqrLUfbUreR18MsNDHLWHRzZKEbF2RGr/view?usp=sharing

	Canopy cover assessments review: To reduce the error in the SU´s impairment category assignment, the imagen analyst reviewed Ortiz-Malavassi's (2017) database consulting additional image repositories available on e.g., SAS Planet and Global Mapper. **Review of selected sampling points:** the coordinator reviewed the selected sampling points to assure that SU corresponds to the degradation category. **Review of field information**: Once finished the field measurement work, the field crew chief verified that every tree, shrub, palm, etc., with DBH > 10 cm had been measured and had the paint mark. Also, the crew chief verified that the plot's central point was recorded in the GPS with the required precision and that the access track was recorded for its location. **Registry of information**: The field forms were reviewed and digitized daily to minimize errors during field measurements and errors during digitally recording data. The collection of all measured trees was managed in an MS Excel template. The data analyst daily reviewed the field forms to identify inconsistencies. If any error were detected, the data analyst requested the crew chief's clarifications. **Independent evaluation of forest inventory data quality:** A separate crew evaluated the quality of forest inventory data. The independent team made field visits and re-measures 5% of the plots (see Annex 1 in Obando, 2019)[60].
Uncertainty associated with this parameter:	
Uncertainty of R_c	The uncertainties were calculated from the standard deviations of the identified relationships.

Forest type	Uncertainty of R_c (%)
Wet and Rain Forests	16%
Moist Forests	22%
Dry Forests	24%
Mangroves	32%
Palm Forests	37%

[60] Obando, G. (2019). COORDINACIÓN GENERAL DE LA IMPLEMENTACIÓN DEL PLAN DE MEJORA DEL NIVEL DE REFERENCIA. Tercer Informe de Consultoría N ° 016-2018-REDD. Retrieved from https://drive.google.com/file/d/1MEHZ6dvQKY52X58UtlG02o4Uw9x1HV6v/view?usp=sharing

3.2 Monitored Data and Parameters

Table 6: Source of Activity Data and description of the methods for developing the data for estimate emissions from deforestation, degradation and carbon removals during the monitoring period.

Parameters:	**Activity Data of Deforestation (AD_D) Eq. 5.1** **Activity Data of Reforestation (AD_R) Eq. 5.2** **Forest remaining forests (AD_{F-F}) Eq. 5.3**
Description:	Deforestation: Hectares of forest that changed to non-forest land in a year summed each year (i) of the monitoring period. Reforestation: Hectares of non-forest that changed to forest land in a year, summed for each year (i) of the monitoring period. Forest remaining forests: Hectares of Forest remaining forests in a year, summed for each year (i) of the monitoring period
Data unit:	Hectares
Source of data	
Introduction	A unique and uniform methodology was used both for FREL / FRL and for the forest emission estimate to avoid that changes registered in the cartographic comparison of LULC maps were affected by the combination of different techniques and methods. Córdoba-Peraza, (2020a;2020b) prepared the LULC Maps 2017 and 2019 of Costa Rica (MCS 2017/18[61] and MCS 2019/20)[62], following the satellite land monitoring protocol (SLMP) developed by AGRESTA (2015) and the protocol for postprocessing developed by Carbon Decisions International (Ministry of the Environment and Natural Resources of Costa Rica, 2016). MCS 2017/18 and MCS 2019/20 maps were included in the 1987-2013 time-series geodatabase. Also, the geodatabase's table of uses, types, and ages of the forest was updated. To automate the workflow, AGRESTA (2015) generated the toolkit ***REDD tools Costa Rica package***. This toolbox runs on the geographic information system QGIS for the Microsoft Windows operating system. The programs were compiled in the QGIS Processing framework[63] allowing to run geoprocessing algorithms implemented in software libraries external to QGIS. The following libraries are used: • GRASS GIS (https://grass.osgeo.org/) • Orfeo Toolbox (https://www.orfeo-toolbox.org/) • GDAL (https://gdal.org/) It was necessary to migrate the toolkit to updated versions of QGIS and update the libraries to 64-bit versions to be able to work with recent versions of Windows, QGIS, and IMN equipment. The updated guide for installing the software tools and the necessary programs to prepare Land-use maps can be consulted in Annex 1 of the Córdoba-Peraza (2019) report. It is important to note that none of these updates results in a change in methodology. The land use maps were created using the methodology summarized here; further information may be found in separate reports [64,65,66,67] :
Data sources for estimating activity data:	The construction of the AD time series required the following sources of data: i. Remotely sensed data from Landsat 8 OLI/TIRS. ii. Mask of the country (in raster format) generated from map MCS 2013/14

[61] LULC map 2017 (MCS 2017/18) can be accessed at the following link: https://drive.google.com/drive/folders/1yARo588uxh_KYccBNaVpokPqqu_pMISL?usp=sharing

[62] LULC map 2019 (MCS 2019/20) can be accessed at the following link: https://drive.google.com/drive/folders/1NRxm3yRV6yT1NgLwhp_z00wxyA0fpMdx?usp=sharing

[63] https://docs.qgis.org/2.8/en/docs/user_manual/processing/

[64] Córdoba-Peraza, J. (2020 a). Informe final Elaboración del mapa de cobertura y uso de la tierra en Costa Rica 2017. Retrieved from https://drive.google.com/file/d/1_p4M48tpPuPrBzm4makYVELb5p6eDSB9/view?usp=sharing

[65] Córdoba-Peraza, J. (2020 b). Informe final Elaboración del mapa de cobertura y uso de la tierra en Costa Rica 2019. Retrieved from https://drive.google.com/file/d/1WPr46RFOu_1Vr5rAYO_QDUlaL090zWd3/view?usp=sharing

[66] Agresta, Dimap, Universidad de Costa Rica, Universidad Politécnica de Madrid. 2015. Final Report: Generating a consistent historical time series of activity data from land use change for the development of Costa Rica's REDD plus reference level: Methodological Protocol. Report prepared for the Government of Costa Rica under the Carbon Fund of the Forest Carbon Partnership (FCPF). 44 pp. https://www.dropbox.com/s/ygjw6zq00a1qtbm/Informe_tecnico_feb_2015.pdf?dl=0

[67] Ministry of the Environment and Natural Resources of Costa Rica. (2016). Modified REDD+ Forest reference emission level/forest reference level (FREL/FRL). COSTA RICA. SUBMISSION TO THE UNFCCC SECRETARIAT FOR TECHNICAL REVIEW ACCORDING TO DECISION 13/CP.19. Retrieved from https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf

	iii. Land-use maps 2013 and 2015 (MCS 2013/14, MCS 2015/16[68]) and Forest's type map (MTB), prepared by AGRESTA (2015) to edit the results of the spectral classification of remotely sensed data and to further stratify the five forest categories "Wet and Rain Forests", "Moist Forests", "Dry Forests", "Mangroves" and "Palm Forests" into the sub-categories "primary forests" and "secondary forest. iv. The Global Forest Change project (Hansen et al., 2013) has been used to fill in pixels without information in the mosaic of classifications for land-use maps 2017 and 2019.
Methods for mapping land-use and land-use change	
Selection of images	To prepare the Land-use map 2017 and 2019 (MCS 2017/18 and MCS 2019/20, images from the LANDSAT 8 OLI / TIRS satellite were used for the period from June 2017 to June 2018 for the land-use map of 2017 and from June 2019 to June 2020 for land-use map of 2019. In both cases, to cover the continental territory of Costa Rica, it was necessary to work with two scenes of path 14 (rows 53 and 54), three scenes of path 15 (rows 52, 53, and 54), and two scenes of path 16 (rows 52 and 53) (see **Error! Reference source not found.**). The following bands used were 2, 3, 4, 5, 6, and 7.
Pre-processing and Geometric validation	It was not necessary to rectify the Landsat8 images supplied by the USGS. These images have a 1T processing level (Terrain corrected), a systematic geometric correction using ground control points for image registration with a WGS84 map projection. These also include correction of relief changes. A mask of the country (in raster format) generated from map MCS 2013/14 of the geodatabase was used to ensure that the maps MCS 2017/18 and MCS 2019/20 are consistent in area, pixel resolution, and dimensions (same number of columns and rows X, Y) with the maps of the 1997-2013 time series. The MCS 2017/18 and MCS 2019/20 map has the same number of columns and rows (c 14554, r 14089) and a spatial resolution of pixels in XY (29.99951157, 29.9995115) to compare them geographically and to obtain the land-use change matrix. Also, a mask of clouds and shadows was prepared to improve the classification. According to the SLMP protocol in Agresta (2015), GRASS "r.mapcalculator" in QGIS 2.4 should have been used for cloud and shadow masking, as well as a SAGA majority filter. However, Fmask 4 (https://github.com/gersl/fmask) was used since this tool is an improved software for the generation of cloud and shadow masks in Landsat and Sentinel images. Finally, all those pixels that do not belong to the country's continental territory were included in the mask of clouds and shadows.
Radiometric normalization	All images were radiometrically normalized. This process is applied to reduce radiometric differences between images due to atmospheric conditions and the sensors' calibration at image acquisition dates. The conversion of digital values (6-band images) to reflectance was made using "Obtain reflectance" tool included in REDD tools Costa Rica package. The time normalization of the images was performed using the zenithal reference angle with a value of 36.90°, corresponding to February 17, 2013. For this procedure, "time normalization" of REDD tools Costa Rica package was used. Finally, for the radiometric normalization of the images, the tool "Radiometric Normalization" of REDD tools Costa Rica was used.
Random Forest classification	The classification of the images uses the Random Forest (RF) method. This methodology has 2 phases: (1) training or adjustment of the RF and (2) classification of the images using the generated RF classifier. Random Forest classifier was trained using homogeneous regions of interest known as ROI's, that provided "ground truth" information. ROIs were prepared by the technical team of the National Meteorological Institute together with the consultant. The ROIs are consistent with the land cover classes established in the satellite land monitoring protocol of Agresta (2015). ROI s were not collected for the paramo class, since a mask developed by Agresta (2015) was used to exclude this type of coverage from the analysis. The information used to define the training zones was the following: i. Google Earth's high-resolution image dataset. ii. Landsat 8 images used in the preparation of the land use map for the year 2017 (MCS 2017/18) and iii. ROIs provided by AGRESTA were used as a guide to delimit the polygons with the coverage classes. In total, 20 predictor variables (also called covariates or auxiliary variables) were used for the adjustment of the RF models, divided into four groups: (1) Spectral information of the bands, (2) Indices of vegetation, (3) Variables related to the texture of the image, and (4) Variables derived from the Digital Elevation Model. The classification of the images was done with the module "Classification of land cover Costa Rica" of REDD Tools Costa Rica in QGIS 2.18, using a ROIs shape file containing the training regions with LULC classes and the image of 20 bands (predictor variables) to be classified.

[68] Córdoba-Peraza, J. (2017). Informe final Elaboración del mapa de cobertura y uso de la tierra en Costa Rica 2015. Retrieved from https://drive.google.com/file/d/15rAwOV9I8jRArkcDnVpkf0tyJyRNu69C/view?usp=sharing

Postprocessing	Final maps are presented at 30 meters resolution. The preparation of the final maps from the classified images included the following tasks: i. The classified images were merged into a mosaic using the classification prioritization algorithm of the "FusionClass" module of REDD tools Costa Rica. ii. Information gaps due to the presence of clouds and shadows, although small, were filled with global data from the Global Forest Change project[69]. iii. MCS 2017/18 and MCS 2019/20 maps were re-projected, using the GDALWARP tool, from the OSGeo4W Shell console. This tool was used considering the geographical properties of the MCS 2013/14 map (pixel resolution, image extension X1-X2, Y1 Y2) as well as the number of rows and columns. iv. Minimum mapping unit: The analyst replaced Forest Class groups of pixels smaller than 11 pixels with the LULC class of the largest neighboring group to comply with the minimum area threshold of the definition of "forest (1.00 ha), and setting the minimum mapping unit. Due to the pixels' dimensions in the Landsat images (30.00 m x 30.00 m), the minimum mapping area is 0.99 ha, equivalent to 11 pixels (11 x 30.00 m x 30.00 m). v. MCS 2017/18 and MCS 2019/20 maps were reclassified according to the Land-use categories of the MCS 2013/14 map. The forests were separated into primary and secondary forest and by life zone (wet and rainy, wet, dry, mangrove and palm forest); permanent and annual crops also were grouped.
Activity Data calculation	For calculating the activity data, a cartographic comparison of the wall-to-wall maps MCS 2017/18 and MCS 1019/20 was made to subsequently count the pixel change and stable pixels in the 2018-2019 transition matrix. It was assured that both maps, MCS 2017/18 and MCS 2019/20 map, met the following requirements: i. Both maps must be in raster format; ii. Both maps must have the same number of rows and columns and the exact pixel resolution; iii. They should be in the same geographical reference system and not being displaced, and the projection should be EPSG 102305 CRTM05; iv. Both maps must share the same classification LULC key used in REDD+ Time Series maps, and v. Both maps must cover the same area. Using the ArcGIS / Zonal / Tabulate Area tool, the land-use change was obtained. The stable and converted areas are reported in land-use change matrices in the sheet "LCM 2018-19" of the FREL TOOL CR developed by Carbon Decision International (CDI) to estimate forest emissions for the period.
Value applied in monitoring period	
	2018-2019: • Total anthropogenic deforestation: **9,403** ha yr^{-1} • Primary forest anthropogenic deforestation: **1,458** ha yr^{-1} • Secondary forest and tree plantation anthropogenic deforestation: **7,945** ha yr^{-1}
QA/QC procedures applied	
Introduction	The QA/QC procedures applied during the preparation of the land-use maps used to calculate AD for the reference period are summarized here, further information may be found in Agresta (2005), Sections 3, 4, and 7:
Download and satellite image preparation	1. Verification of file storage errors in digital media that could affect reading the data by the analyst responsible for download support images. 2. Previewing and verification of the satellite image quality and metadata by the analyst responsible for downloading support images. 3. Previewing and verification of the satellite image quality and metadata by the supervisor (IMN specialist).
Image orthorectification	Landsat 8 images are already orthorectified, therefore it was not necessary to apply the QA / QC procedure.
Radiometric normalization:	4. Radiometric normalization to reduce the differences between the time-series images.
Generation of cloud and shadow masks	5. The cloud and shadows mask were not validated with checkpoints. Instead, the analysts performed an exhaustive visual inspection.
Land use classification:	6. Analysts perform an iterative process of classification, verification of results, error detection, and review of areas and training points.

[69] Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, A., Tyukavina, D., Thau, D., Stehman, S.J.m Goetz, T.R., Loveland, T.R., Egorov, A., Chini, L., Justice, C.O. & Townshend, J.R.G. 2013: High – Resolution Global Maps of 21st-Century Forest Cover Change http://science.sciencemag.org/content/342/6160/850.

	7. Progressive improvement of the areas and training points of the RF classifier before the final classification of the images. Review of the Random Forest classifiers' errors, identify classes that need improvement, and training points. 8. Visual verification and validation of classified images by comparing them with the available high-resolution image.
Preparation and validation of land-use maps:	9. Visual check of mosaics and identify information gaps (sensor failures on each time series' images. It is essential to clarify that Landsat 8 does not present the banding problems of Landsat 7. Therefore, it was not necessary to check for sensor errors. 10. Visual verification of the maps generated after filling the gaps with global data. 11. Manual edition of the time-series classification to improve land use mapping, largely aimed at decreasing high classification errors.
Preparation and validation of land-use change map:	12. Visual verification of the country's main deforestation and reforestation areas between consecutive years of the series to detect classification errors. 13. Validation of land-use changes between 2018 and 2019 based on photointerpretation of changes on a systematic random grid of points with high-resolution images of the year 2018 and 2019.
Uncertainty associated with this parameter:	
	Uncertainties associated to AD are due to the production process of land-use maps. The uncertainties of the AD for land-use change activities (deforestation and reforestation) and forest remaining forest activities (degradation and enhancements in forest lands) come from the uncertainties associated with the process creating land use change maps from which the activity data are obtained. The accuracy assessment of the land-use change map 2017/18 – 2019/20 was done following Olofsson et al.'s (2014)[70] guidelines. Reference data were collected by Ortiz-Malavassi (2020)[71]. The following is a summary of the sampling design for the collection of Refence Data: **Type of sampling:** Systematic Sampling **(**SYS) over the Level 1 Systematic Grid of 10,242 points of the Monitoring system of land use change and ecosystems (SIMOCUTE). The SIMOCUTE sampling units are permanent, which facilitates reinterpretation through time and easy temporal tracking of LULC changes. **Sampling Unit:** Multi-point Sampling Unit (SU). The SU is a 2-ha square plot with a 5x5 point sub-grid (25 points within the sampling plot). This plot size allowed for a better evaluation of land use if images of lower spatial resolution must be used, as in the case of images from the Planet or Sentinel platform. A unique land-use dominance class is recorded at SU level for t1 and t2. The change class is calculated using the dominance class at t1 and t2 at SU level. **Number of Sampling Units:** A total of 9988 checkpoints were assessed in the country's territory (excluding Cocos's island). **Classification scheme:** Due to a large number of land-use change transitions, they were aggregated into four categories: Deforestation (forest to non-forest), new forests (non-forest to forest), stable forest (forest remaining forest), and stable non-forest (non-forest to non-forest). **Data sources**: The reference data for the validation of land-use changes during the period 2017/2018 -2019/2020 was collected from visual interpretation of high-resolution images, During the visual interpretation, priority was given to the high-resolution images available in Google Earth, for 2018 (July 1, 2017 to June 30, 2018) and 2019 (July 1, 2019 to June 30, 2020). In the absence of images of less than 4 m resolution, the Planet images available in the NICFI Program[72] were used, and in the second instance Sentinel-2 or Landsat 8 within the priority dates. **Interpretation Key**: A revised version of the SIMOCUTE key was used to interpret land-use, following specific rules and spatial contexts such as size and shape of forests and considerations regarding gallery forests, rivers, and lake protection zones (see Annex 1 of Ortiz-Malavassi, 2020). **Data collection**: The following procedures were applied during the collection of reference data: i. Cold checks: random check of the interpretations. Sixty points were randomly chosen, in which the supervisor reviewed the analysts' land use interpretations. Twenty sampling points were randomly selected from each analyst. An external analyst examined the results of the land-use classification and provided feedback to the analysts. In case of discrepancy, the external analyst defines the use observed image. The minimum level of consistency between the analyst and the external analyst was 95%, for

[70] Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148, 42-57.
[71] Ortiz-Malavassi, E. (2020). Apoyo técnico para el registro de datos de cambio de uso del suelo mediante el método de Evaluación Visual Multitemporal (EVM) para el periodo 2018-2019. Retrieved from https://drive.google.com/file/d/1Bcv8qTLH8TGkbvYQpIPIGhAJ2xbzIYk8/view?usp=sharing
[72] Norway's International Climate and Forests Initiative Imagery Program https://www.planet.com/nicfi/

	the transitions (stable forest, deforestation, and reforestation). ii. Hot checks: the supervisor provided immediate feedback to the analysts to improve the interpretations through the weekly review of points. 4 points are chosen per analyst each week, different from the sampling points selected for the cold checks. The "hot checks" also contemplate the revision of doubtful classification. **Data analysis**: The dominance class was defined considering a threshold of 30% forest cover. If the forest area is greater than 30%, the sampling plot is classified as forest land. The estimate of land-use change areas is not based on dominance class (DC) in t1 and t2. DC was used to identify potential land-use change points (See Figures 3A and 3B). A total of 54 sample plots were defined as possible deforestation or regeneration points. These plots were re-analyzed, and the change at point level in the 5x5 sub-mesh was recorded. Only the sampling plots where the supervisor confirmed the land-use change were considered valid points for estimating the change areas. The accuracy assessment analysis for the period 2018-2019 is presented in the Excel file ¨ReferenceData2018-2019Rev12Feb2021.xlsx”[73]. The Stratified sampling tool for area estimation was used to calculate land-use change areas, developed by FAO Open Foris project and available at https://github.com/openforis/accuracy-assessment. The activity data's uncertainty is the bias between the adjusted (reference data in cells H10-H14 in spreadsheet “SepalMC19v2” of ReferenceData2018-2019Rev12Feb2021.xlsx) and estimated areas (land use maps in cells G10-G14 in spreadsheet “SepalMC19v2” of ReferenceData2018-2019Rev12Feb2021.xlsx). The uncertainty values for the monitoring period 2018-2019 are as follows: Uncertainty of hectares of deforestation from 1998-2011: 6% Uncertainty of hectares of non-forest that changed to forest land: 8% Uncertainty of hectares of forests remaining forests in 1998-2011: 12%

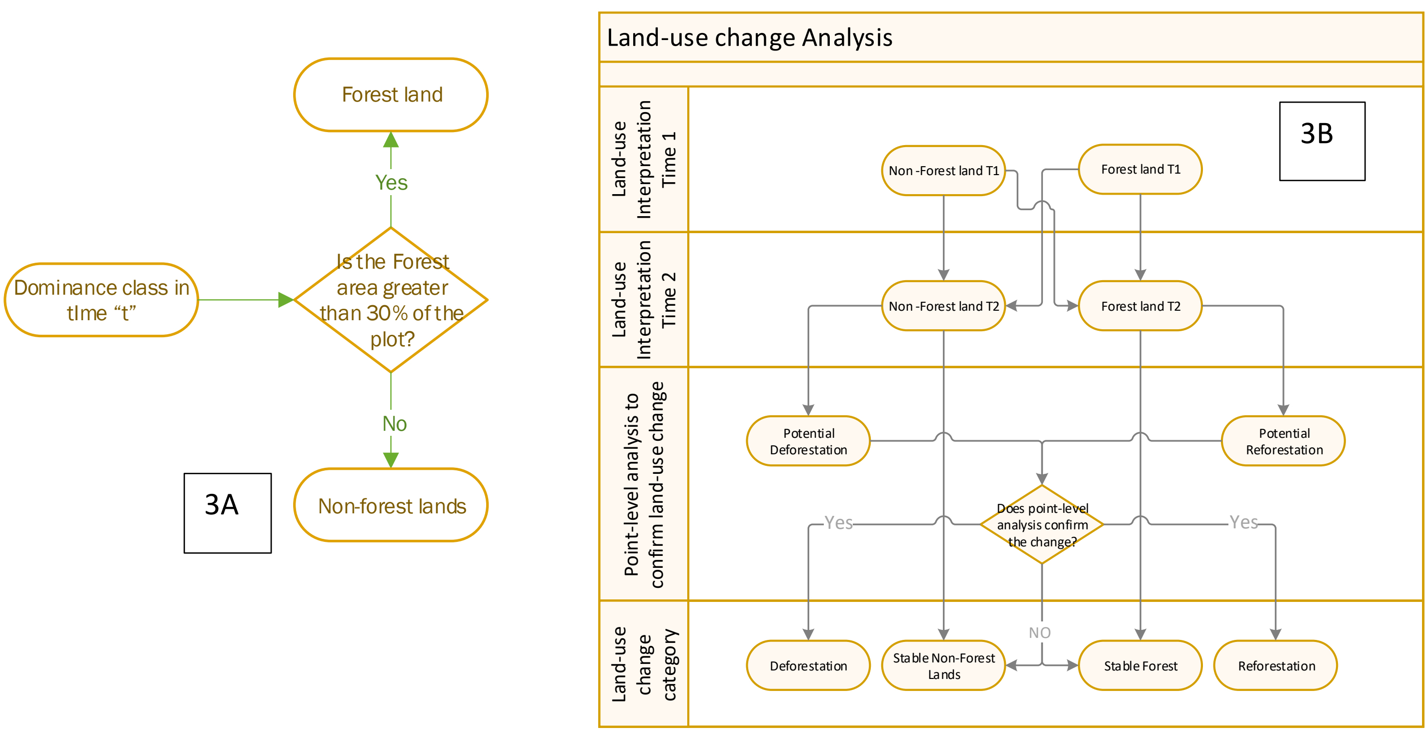


Figure 2: A. The dominance class was defined considering a threshold of 30% forest cover. If the forest area is greater than 30%, the sampling plot is classified as forest land. (B) The estimate of land-use change areas is not based on dominance class (DC) in t1 and t2. DC was used to identify potential land-use change sampling points. These plots were re-analyzed; only the sampling plots where the supervisor confirmed the land-use change were considered valid points for estimating the land-use change areas.

[73] Accuracy Assessment 2018-2019 analysis can be accessed in the following: link https://drive.google.com/file/d/1l-47qEum84ksEYC-ndmmePDFkxCj4SNz/view?usp=sharing

Table 7: Source of Activity Data and description of the methods for developing the data for estimate emissions from degradation during the monitoring period.

Parameters:	**Activity Data of Degradation (AD_{Deg}) Eq 5.4** **Activity Data of Permanent Forest Regeneration (AD_E) Eq. 5.5**
Description:	Degradation: Hectares of forest with a reduction of canopy cover during the monitoring period. Forest Enhancement: Hectares of forest with an increase of canopy cover during the monitoring period
Data unit:	Hectares
Source of data	
Introduction	The forest degradation assessment was made on forest lands that remain as forest lands. The analysis of degradation was only performed on the area of forest remaining forest according to the land-use MCS 2017/18 map to avoid double-counting of baseline emissions between deforestation and forest degradation. This procedure avoided any measurements of degradation that were also accounted for under deforestation. Reference data to estimate Degradation AD were collected by Aguilar (2020)[74].
Type of sampling	A Systematic Sampling (SYS) over the updated version of Level 1 Systematic Grid with 10,825 points of the Monitoring system of land-use change and ecosystems (SIMOCUTE) was used. The original systematic grid is in the CRTM05 coordinate system of Costa Rica. However, it was re-projected to geographic coordinates in WGS84 to evaluate the sampling point with the Collect Earth Desktop tool. The SIMOCUTE sampling units are permanent, which facilitates reinterpretation through time and easy temporal tracking of LULC changes.
Sampling Unit	The Sampling Unit (SU) is a 90x90 meter plot whose central point coincides with the SIMOCUTE sampling points. The SU corresponds to 3x3 Landsat pixels and covers 0.98 ha. Inside SU, a 7x7 points sub-grid was created to estimate land cover percentage within each sampling unit.
Number of Sampling Units	The forest degradation assessment was made on forest lands that remain as forest lands during 2017-2019. The 4377 points classified as permanent forest land according to the MCS 2012/13 map were assessed in this monitoring period. These points are an extract from the Systematic Grid adopted in SIMOCUTE.
Classification scheme	Three classes of canopy cover were considered to estimate degradation/enhancement in permanent forest land: i. Intact forest (85-100% forest cover), ii. Degraded forest (60-85% forest cover), and iii. Very degraded forest (<60% forest cover). The following forest cover change classes were assessed by forest type and type of carbon fluxes (anthropogenic and natural): Degradation: a. Intact to Degraded forest b. Intact to Very degraded forest c. Degraded to Very degraded forest Forest enhancement: d. Very degraded to intact forest e. Very degraded to degraded forest f. Degraded to Intact forest No Condition changes g. Stable intact forest h. Stable degraded forest i. Stable very degraded forest
Data Sources	The range of dates of the images presented in the table below was used. Priority was given to operating with high-resolution dated imagery available in Google Earth. The next priority was to use the dated Planet images available in the NICFI Program.

[74] Aguilar, L. (2020). Evaluación Visual Multitemporal para la determinación de la degradación forestal para los periodos 2014-2015-2017-2019 y determinación de datos de referencia para periodo 2017-2019. Tercer Informe. Retrieved from https://drive.google.com/file/d/1ERutZo6vNI6MXUCmlrky7wiaeOqOLMqh/view?usp=sharing

Table 8: Data sources and Imagery date range used in the canopy cover evaluation on permanent forest for the monitoring period 2018-2019.

Monitoring Year	Imagery date range	Data sources
2018	July 2017 – June 2018	• Google Earth dated high-resolution imagery repository (CNES/Airbus, Maxar Technologies) • Planet dated imagery of NICFI Program • Other sources (Bing Map, Copernicus, Landsat 7, US Geological Survey)
2019	July 2019 – June 2020	

Interpretation Key

The Version 1.2. 2018. SIMOCUTE land cover class key was used to determine canopy cover:

Table 9: Land cover key used in the land cover evaluation protocol for the years 2018, and 2019.

Code	Land cover class
1100	Trees
1200	Shrubs
1300	Herbaceous
1400	Palm
Not included	Bromeliads
1500-1600	Greenhouse
1700	Other vegetation
2000-2200	No vegetation
3000	Water
4000	Clouds and shadows
5000	Not classifiable

Data collection

See QA/QC procedures.

Data analysis

The country developed a tool for calculating emissions and removals on permanent forest lands (¨Herramienta_degradación.xlsx¨ [75]). The database for the visual interpretation of canopy cover for the period 2016-2018 and monitoring period 2018-2019 are included in the sheet "Base_de_datos”. The area of degraded and enhanced forest areas was extrapolated to the forest area in the entire country through proportional representation within the respective degradation classes (intact, degraded and very degraded) and forestry type. Degradation classes were determined based on the reduction of the forest canopy cover, by which intact forests have a cover of 85-100%, degraded forests have a cover of 60-85%, and very degraded forests a cover between 30% and 59%. Forest areas that went from intact to degraded, intact to very degraded, or degraded to very degraded (in terms of their canopy cover) during the assessment period (1998-2011) were classified as degraded. Forest areas that went from very degraded to degraded, very degraded to intact, or degraded to intact were identified as forest enhancement areas. Carbon fluxes were estimated for anthropogenic and natural conditions. Fluxes from sampling points inside protected areas and farther than 500 meters from a road were considered natural fluxes and removed from reference level accounting. The estimation of the areas of change of degradation and canopy enhancement, for both anthropic and natural carbon fluxes, can be found in the sheet ¨Resumen_de_puntos¨ of the Degradation tool, for the monitoring period 2018-2019. It is important to indicate that it was unnecessary to update proximity analysis to roads and protected areas to estimate anthropogenic carbon flux since the 1: 5000 layer of roads and the layer of protected areas have not been updated.

Value applied in monitoring period:

- **2,194,030** hectares of forests remaining forests in the monitoring period (2018-2019)
- **55,130** hectares of anthropogenic degradation (2018-2019)
- **39,538** hectares of anthropogenic forest enhancement (2018-2019)

QA/QC procedures applied

[75] Degradation tool can be accessed in the following link: https://drive.google.com/file/d/1GG3Z_QMWBKGNRdXnF_TdWP1ipH9dX5iH/view?usp=sharing

	Aguilar (2020) prepared a land cover evaluation protocol to reduce the uncertainty of the land cover classification due to: a) the bias associated with the spatial registration of the reference image, b) the interpreter bias in the assignment of the land cover class; and c) interpreter variability. The following procedures were applied during the collection of reference data: **Consideration of spatial and temporal context**: The protocol includes a procedure for canopy cover change interpretation considering the spatial and temporal context (see section 1.6 in Aguilar, 2020). **Reference order of the repositories of images**: The analyst gave priority to high-resolution images in Google Earth. In the second instance, on the Planet images available for the monitoring period. In case there are no high-resolution images for any sampling points, lower-resolution images available in the Collect Earth Desktop tool were used, as long as the monitoring period images are equal or better quality than the 2017 assessment. **Data registry forms**: The canopy cover change information was recorded in standard Collect Earth Desktop forms (see section 1.7 in Aguilar, 2020). **Training**: The supervisor trained the interpreters before starting the interpretation of plots to calibrate and leave clear procedures to collect the most accurate information possible. **Supervision of interpreters ("Hot Checks"):** The supervisor opened remote sessions between the coordinator and the interpreter (due to the Covid); to oversee the evaluation process without intervening. The coordinator presented the results in periodic sessions with all interpreters to improve the group of interpreters' criteria. The supervisor resolved the consultations of the interpreters online. **Checking of interpretations by the supervisor, without interpreters' presence ("Cold Checks"):** The supervisor reviewed at least 5% of the parcels evaluated. The points that do not coincide were reviewed together by the supervisor and all the interpreters. **Checking of interpreters' consistency ("Blind Checks"):** The analysts performed this procedure at the end of interpreting all the sampling plots. Each analyst evaluated at least 5% of the assessed plots by other interpreters, e.g., Interpreter 1 reviewed interpreters 2 and 3. The minimum level of consistency between evaluators was 90%. If not complying with the standard, the interpreter team should review the work until reaching the 90% threshold. **Consistency between reference and monitoring period data**: The analyst reviewed the consistency of 2018 canopy cover data with the 2016 evaluation performed by Ortiz-Malavassi (2017). **Treatment of plots with forest cover less than 30%:** The analyst made the degradation analysis over the systematic grid points that falls on permanent forest lands during 1998-2011 in REDD time series maps. Thus, the 4,377 points of the original sampling implemented by Ortiz-Malavassi (2017) were re-visited in 2016, 2018, and 2020 evaluations. During the review of these points, some of them passed to non-forest conditions due to the loss of coverage and non-compliance with the minimum forest definition area (30% of canopy cover). Some of these points may have been declared deforestation or being part of the omission error in the land-use change's permanent forests for the periods 2012-13, 2014-15, 2016-17, 2018-19.
Uncertainty associated with this parameter:	In the assessment of degradation level in forests remaining forests, it was assumed that there was no uncertainty associated with the visual interpretation of sample areas because this procedure employed visual classification of canopy cover using high resolution imagery, as described above. Uncertainty of changes in canopy cover to identify areas of degradation and forest enhancement from 2018-2019 vary depending on the forest type and the conversion class. It is based on the sampling error.

4 QUANTIFICATION OF EMISSION REDUCTIONS

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

Costa Rica made technical corrections to the Reference Level of the ER program. These corrections are not related to any change to policy and design decisions that could affect the Reference Level (carbon pools and gases, GHG sources, reference period, forest definition, REDD+ activities, Accounting Area, forest types, and REDD+ activities). The country has replaced emission/removal factors for degradation by higher precision EF based on additional sample plots and corrected an error in the canopy cover change database during the identification of very degraded forests. Paragraph 3 positive list of the Guideline on the application of Methodological Framework Number 2 includes these technical corrections. Costa Rica has updated the FREL/FRL by recalculating the forest degradation emissions, as follows:

a. Increasing the number of field observations, following the methodology used in the NFI to determine aboveground biomass in 100 temporary degradation plots covering all forest types (i.e., wet and rain forests, moist forests, dry forests, mangroves, and palm forests). These new data were integrated into aboveground biomass vs. canopy cover models used to develop new degradation emission factors.

b. Updating the degradation categories in the aboveground biomass vs. canopy cover models as: intact forests have a cover of 85-100%, degraded forests have a cover of 60-85%, and very degraded forests a cover of 30-59%. Forest areas that went from intact to degraded, intact to very degraded, or degraded to very degraded (in terms of their canopy cover) during the reference period (1998-2011) were classified as degraded, whereas primary forest areas that went from very degraded to degraded, very degraded to intact, or degraded to intact were identified as forest enhancement areas.

c. An error was corrected in the database identifying forests classified as previously degraded. Prior to this correction, forests with a canopy cover of between 0% and 59% were classified as very degraded. To account for the fact that areas with less than 30% canopy cover are identified as non-forests, this classification was corrected to only include forests with a canopy cover between 59% and 30%.

d. Further, the methodology to estimate total uncertainty was updated as the previous approach of estimating the final confidence interval of the final distribution of Monte Carlo simulations was deemed to have led to unrealistically low values.

Further detail about the adjustments made to the reference level as compared to that the estimates provided in the most recent version of the ER Program Document are presented in detail in Annex 4.

Year of Monitoring / Reporting period *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, 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)
2018	5,985,795	1,383,974	-4,784,051	NA	2,585,717
2019	5,985,795	1,383,974	-4,784,051	NA	2,585,717
Total	**11,971,589**	**2,767,948**	**-9,568,102**	**NA**	**5,171,435**

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

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, the equations 2-5 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. As in the Reference Level period, the total emissions or removals associated with each of the REDD+ activities were calculated as the Annual emissions or removals were estimated for all land transitions ¨*i*¨ by REDD+ activity, and then adding the results for all selected REDD+ activities for each year:

$$RL_{RP} = \frac{\sum_{t=1}^{RP} ER_{RA_t}}{RP} = \frac{\sum_{t=1}^{RP} \sum_{i=1}^{I} \left(AD_{RA_{i,t}} * EF_{RA_{i,t}}\right)}{RP}$$

Equation 3

Where:

ER_{RA_t}	=	Emissions or removals associated to REDD+ activity *RA* in year *t*; tCO_2-e yr^{-1}
$AD_{RA_{i,t}}$	=	AD associated to REDD+ activity *RA* for the land use transition *i* in year *t*; ha yr^{-1}
$EF_{RA_{i,t}}$	=	EF associated to REDD+ activity *RA* applicable to the land use transition *i* in year *t*; tCO_2-e ha^{-1}
RP	=	Reference Period in years
i	=	A land use transition represented in a cell of the land use change matrix; dimensionless
I	=	Total number of land use transitions related to REDD+ activity *RA*; dimensionless
t	=	A year of the historical period analyzed; dimensionless

REDD+ Secretariat of Costa Rica estimated emissions by sources and removals by sinks included in the ER Program with two separate integration tools: deforestation and degradation[76]. The country also prepared an Emission Reduction Calculation Tool based on the FREL and Degradation tool results[77].

Year of Monitoring / Reporting 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)
2018	826,324	2,513,265	-6,098,753	-2,759,164
2019	854,009	2,513,265	-5,922,964	-2,555,690
Total	1,680,333	5,026,529	-12,021,717	-5,314,854

4.3 Calculation of emission reductions

Total Reference Level emissions during the Reporting Period (tCO_2-e)	5,171,435
Net emissions and removals under the ER Program during the Reporting Period (tCO_2-e)	-5,314,854
Emission Reductions during the Reporting Period (tCO_2-e)	10,486,289

[76] FREL and Degradation TOOL can be accessed in the following link: https://drive.google.com/drive/folders/1j5ogQjh6UBUkSw45m_eHmT60ey6FDeDS?usp=sharing
[77] Emission Reduction Calculation tool can be accessed in the following link: https://drive.google.com/file/d/1WDtlCl080dxOrlGRmydeOMCIy0eZdL_q/view?usp=sharing

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

5.1 Identification, assessment and addressing sources of uncertainty

Table 10: Sources of uncertainty to be considered under the FCPF MF

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Activity Data					
Measurement	Systematic and random	**Land-use change areas (deforestation, reforestation and forest remaining forest areas)**: A unique and uniform methodology was used both for FREL / FRL and for the forest emission estimate to avoid that changes registered in the cartographic comparison of LULC maps were affected by the combination of different techniques and methods. This error represents the operator error during preparation and interpretation of LULCC maps. This error is reduced by the following QAQC procedures (see table 2 and 6). Quality control was first conducted during the download and image preparation phase by reviewing storage errors that affect the reading of the data, analyzing the image's metadata, and visually previewing the original image. The scenes of the reference period were analyzed by conducting the following image orthorectification procedures: i. Using control points, verify that the average square error never exceeds the pixel size of the image, ii. Visually inspect the image to ensure that there has been no defect in the orthorectification process (i.e., duplicate areas, pixel deformation, or geometry errors caused by errors in the digital terrain model), and iii. Using a regularly distributed grid, take checkpoints in each scene and perform geometric control of rectified images. For the scenes of monitoring period, it was not necessary to rectify the Landsat8 images supplied by the USGS. These images have a 1T processing level (Terrain corrected), a systematic geometric correction using ground control points for image registration with a WGS84 map projection. These also include correction of relief changes A radiometric normalization was applied to reduce the differences between the time-series images. The cloud and shadow masks in all images were then checked by visually comparing them with the original image in RGB or false color. These masks were then validated in a sample of 18 images by visual verification of a systematic grid of checkpoints. Further quality control measures were taken through an iterative process of land use classification, verification of classification, error detection, and review of areas and training points. Errors from the Random Forest classifier were reviewed, classes and training points that needed to be improved were	Low	Yes	No

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		identified, and classifications were visually checked against high resolution images. The final maps were prepared after mosaiced images were visually checked and information gaps and sensor failures on each of the dates in the series were identified. The final maps were subject to a quality assurance (QA) process that was provided by institutions of the country not used in the classification phase. These reviewers validated the final maps on three of the dates in the time series.			
Measurement	Systematic and random	**Permanent forest degradation and regeneration**: The same methodology was used to estimate degradation and regeneration in permanent forest lands. A Systematic Sampling (SYS) over the Level 1 Systematic Grid of 10,242 points of the Monitoring system of land-use change and ecosystems (SIMOCUTE) was used. The analysis of degradation was only performed on the area of forest remaining forest according to the land-use MCS 2017/18 map to avoid double-counting of baseline emissions between deforestation and forest degradation. This procedure avoided any measurements of degradation that were also accounted for under deforestation. In the assessment of degradation level in forests remaining forests, it was assumed that there was no uncertainty associated with the visual interpretation of sample areas because this procedure employed visual classification of canopy cover using high resolution imagery, as described above in tables 3 and 7. The following QA/QC procedures were applied during the interpretation of high-resolution imagery: i. **Consideration of spatial and temporal context**: The protocol includes a procedure for canopy cover change interpretation considering the spatial and temporal context (see section 1.6 in Aguilar, 2020). ii. **Reference order of the repositories of images**: The analyst gave priority to high-resolution images in Google Earth. In the second instance, on the Planet images available for the monitoring period. In case there are no high-resolution images for any sampling points, lower-resolution images available in the Collect Earth Desktop tool were used, as long as the monitoring period images are equal or better quality than the 2017 assessment. iii. **Data registry forms**: The canopy cover change information was recorded in standard Collect Earth Desktop forms (see section 1.7 in Aguilar, 2020). iv. **Training**: The supervisor trained the interpreters before starting the interpretation of plots to calibrate and leave clear procedures to collect the most accurate information possible. v. **Supervision of interpreters ("Hot Checks"):** The supervisor opened remote sessions between the coordinator and the interpreter (due to the Covid); to oversee the evaluation process without intervening. The coordinator presented the results in periodic sessions with	Low	Yes	No

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		all interpreters to improve the group of interpreters' criteria. The supervisor resolved the consultations of the interpreters online. vi. **Checking of interpretations by the supervisor, without interpreters' presence ("Cold Checks"):** The supervisor reviewed at least 5% of the parcels evaluated. The points that do not coincide were reviewed together by the supervisor and all the interpreters. vii. **Checking of interpreters' consistency ("Blind Checks"):** The analysts performed this procedure at the end of interpreting all the sampling plots. Each analyst evaluated at least 5% of the assessed plots by other interpreters, e.g., Interpreter 1 reviewed interpreters 2 and 3. The minimum level of consistency between evaluators was 90%. If not complying with the standard, the interpreter team should review the work until reaching the 90% threshold. viii. **Consistency between reference and monitoring period data**: The analyst reviewed the consistency of 2018 canopy cover data with the 2016 evaluation performed by Ortiz-Malavassi (2017). ix. **Treatment of plots with forest cover less than 30%:** The analyst made the degradation analysis over the systematic grid points that falls on permanent forest lands during 1998-2011 in REDD time series maps. Thus, the 4,377 points of the original sampling implemented by Ortiz-Malavassi (2017) were re-visited in 2016, 2018, and 2020 evaluations. During the review of these points, some of them passed to non-forest conditions due to the loss of coverage and non-compliance with the minimum forest definition area (30% of canopy cover). Some of these points may have been declared deforestation or being part of the omission error in the land-use change's permanent forests for the periods 2012-13, 2014-15, 2016-17, 2018-19. Finally, uncertainty of changes in canopy cover to identify areas of degradation and forest enhancement from reference and monitoring periods vary depending on the forest type and the conversion class. It is based on the sampling error.			
Representative ness	Systematic	**Land-use change areas (deforestation, reforestation and forest remaining forest areas)**: Land-use change areas (deforestation, reforestation and forest remaining forest areas): To prepare the LULCC maps for reference and monitoring periods, four generations of LANDSAT satellites were used: Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM +, Landsat 8 OLI / TIRS. Scenes were selected from June (Year 1) to June (Year 2) for the period under monitoring. Monitoring occurs every two years, and the territorial forest area covered includes the country's continental territory but excludes the Coco Island due to its exclusion from anthropogenic intervention.	Low	Yes	No

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		To ensure the representativeness of the LULCC maps, the Random Forest methodology is used for the reference and monitoring periods to train a forest classifier and then classify imagery. To train the forest classifier, regions of different land cover classes were digitized using (1) a systematic grid of 10,000 points from Rapideye images developed by SINAC, (2) high-resolution images from Rapideye, and (3) current and historical Google Earth images. This base data was then combined with 20 predictor variables to adjust the forest classifier models. To minimize the error (i.e. uncertainty) in these classifier models, the Random Forest R package generates an error and confusion matrix which allows for an initial quality control check based on a subset of checkpoints. To further minimize uncertainty, the random forest classifier was iteratively improved by analysts using the error and confusion matrix generated by the classifier, which identifies classes that need improved training data or predictor variables. Once the classifiers were trained, they were applied to all images to assess land use land cover for the given two-year period. The resulting land use land cover maps then underwent post processing to further reduce uncertainty in classification, through visual comparison of classified maps and high-resolution imagery, analysts performed manual edition of the time- series classification aimed at decreasing high classification errors. Analysts also performed visual verification of the country's main deforestation and reforestation areas to detect any classification errors to ensure an accurate assessment of land use-change. **Permanent forest degradation and regeneration**: High-resolution imagery used to estimate degradation and regeneration were selected from June to June for the year under monitoring.			
Sampling	Random	**Land-use change areas (deforestation, reforestation and forest remaining forest areas)**: Uncertainties associated to AD are due to the production process of land use maps. The uncertainties of the AD for land use change activities (deforestation and reforestation) and forest remaining forest activities (degradation and enhancements in forest lands) come from the uncertainties associated with the process creating land use change maps from which the activity data are obtained. The accuracy assessment of the land-use changes map MCS 2001/02, MCS 2011/12, MCS 2017/18, and MCS 2019/20 was done following Olofsson et al.'s (2014)[78] guidelines. Due to a large number of land-use change transitions, they were aggregated into four categories: Deforestation (forest to non-forest), new forests (non-forest to forest), stable forest (forest remaining forest), and stable non-forest (non-forest to non-forest). For further detail of the accuracy assessment for the reference and monitoring periods please see the uncertainty section in tables 3 and 6.	Low	Yes	Yes

[78] Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148, 42-57.

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
	Random	**Permanent forest degradation and regeneration**: The same methodology was used to estimate degradation and regeneration in permanent forest lands for reference and monitoring period. A Systematic Sampling (SYS) over the Level 1 Systematic Grid of 10,242 points of the Monitoring system of land-use change and ecosystems (SIMOCUTE) was used. Uncertainty of changes in canopy cover to identify areas of degradation and forest enhancement for reference and monitoring vary depending on the forest type and the conversion class. It is based on the sampling error.	Low	No	No
Extrapolation	NA	This source of uncertainty is not applicable. Costa Rica generates estimates of deforestation, regeneration, and permanent forest lands per forest type, where the total annual areas are the sum of each forest type for a given year.	NA	NA	NA
Approach 3	NA	This source of uncertainty is not applicable. Activity data were estimated conducting tracking of lands or IPCC Approach 3 for reference and monitoring periods.	NA	NA	NA
Emission Factor					
DBH measurement H measurement Plot delineation	Systematic and Random	Extensive quality control procedures were implemented prior to the start of field work during estimation of AGB in the National Forest Inventory and Canopy cover and biomass relationship with additional temporal sampling plots. Field crews were organized by region. Each field crew was trained and provided with manuals to assist with identification, collection, transport, and processing of botanical samples. A terms of reference document was also provided which explained specific roles and responsibilities of each crew member. Finally, an Excel template was created to control the quality of data collection. Quality assurance measures were then taken as supervisors visited field sites to oversee the field crews and take photographic records of each field plot (please see tables 4 and 5). The quality of forest inventory data then underwent an evaluation by an independent crew that visits and remeasures 10% of the plots established in the NFI and 5% of the 100 additional plots. Thanks to these QA/QC procedures implemented before, during, and after the field campaigns the potential biases in the measurement of DBH, H, and plot delineation have been minimized. The random error associated with the measurement of these parameters has therefore been considered to be low, and thus this source of error will not be propagated.	Low	Yes	No
Wood density estimation	Systematic and Random	The wood density values were obtained directly from specialized publications (Biomass estimation tool developed by SINAC, IPCC 2003[79]; Myers 2013[80]; Tree Functional Attributes and Ecological	Low	Yes	No

[79] IPCC. 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry. Intergovernmental Panel on Climate Change (IPCC). Edited by Jim Penman, J.; Gytarsky, M.; Hiraishi, T.; Krug, T.; Kruger, D.; Pipatti, R.; Buendia, L.; Miwa, K.; Ngara, T.; Tanabe K.; Wagner, F. IPCC National Greenhouse Gas Inventories Programme. Published by the Institute for Global Environmental Strategies (IGES) for the IPCC. 583 p.

[80] Myers, R. 2013. Fenología y crecimiento de Raphia taedigera (Arecaceae) en humedales del noreste de Costa Rica. En:Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744) Vol. 61 (Suppl. 1): 35-45

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		Database, 2018[81]). High-skilled specialists conducted the tree identification following specific protocols to mitigate the error when the wood density value was assigned to each tree.			
Biomass allometric model	Systematic and Random	The biomass was calculated using Chave et al. (2005) for NFI inventory data, and Chave et al. (2014) for the 100 additional AGB plots. The propagation of error through MC simulation did not include this source of uncertainty due to the complexity of calculation, the lack of bias (given errors from allometric equations are not systematic), and the agreement of experts in the fields and of standards (cf. ART) that it is reasonable to exclude this form of error (Winrock International, personal communication, 2021).	Low	No	No
Sampling	Random	Sampling error is the statistical variance of the estimate of aboveground biomass, dead wood or litter. This source of error is random and is considered to be high and it has been propagated. In Costa Rica, sampling error was identified for aboveground biomass values in primary forests in its National Forest Inventory. In secondary forests and in other carbon pools, sampling error of biomass values was estimated from scientific literature. Sampling error was also identified when estimating the ratio between canopy cover and aboveground biomass based on plot data.	High	No	Yes
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	Systematic and Random	Below ground biomass (BGB) is derived directly from Cairns et al., (1997)[82]. The carbon fraction employed was PCC's default value (0.47). The propagation of error through MC simulation did not include either the uncertainty of the root-shoots rations or carbon fraction.	Low	No	No
Representative ness	NA	This source of uncertainty is not applicable. Costa Rica generates estimates of carbon stocks per forest type.	NA	NA	NA
Integration					
Model	Systematic	Manuals have been prepared for the correct use of FREL and Degradation tools[83], to avoid errors during the process of data preparation.	Low	Yes	No
Integration	Systematic	The Emission factors were calculated for each forest type according to AGB sampling plots' location to assure the comparability between transition classes of the Activity Data and those of the Emission Factors. This source of uncertainty is considered in the sampling error of the AGB inventory.	Low	No	No

[81] Tree Functional Attributes and Ecological Database. (2018). Wood Density. Recuperado el 10 de 12 de 2018, de http://db.worldagroforestry.org/.
[82] Cairns M.A., Brown S., Helmer E.H., and Baumgardner G.A. (1997). Root biomass allocation in the world's upland forests. Oecologia 111:1-11.
[83] The manual of FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1INuL5Jld7nlKVsAf7mRsEepm2n8WRVpT/view?usp=sharing

5.2 Uncertainty of the estimate of Emission Reductions

Parameters and assumptions used in the Monte Carlo method

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Area (hectares) of deforestation	10,774 ha in 2018 and 2019	Sampling error	Truncated normal	Minimum value assumed to be 0
Area (hectares) of forests remaining forests	2,198,453 ha in 2018 and 2,194,822 ha in 2019	Sampling error	Truncated normal	Minimum value assumed to be 0
Area (hectares) of new forests	1,850,719 ha in 2018 and 2019	Sampling error	Truncated normal	Minimum value assumed to be 0
Change in percent canopy cover in degraded and regenerated forests	Varies depending on the level of degradation and regeneration	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for very moist and rain forests – primary	313.69	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for moist forests - primary	203.99	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for dry forests – primary	199.19	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for mangroves – primary	253.74	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for palm forest - primary	229.81	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for secondary forests	Varies depending on age (1-400 years) and forest type	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for annual cropland	83.57	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for permanent cropland	Varies depending on age (1-400 years)	Sampling error	Truncated normal	Minimum value assumed to be 0

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Aboveground biomass for paramos	126.87	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for very moist and rain forests – primary	71.97	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for moist forests - primary	48.32	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for dry forests – primary	47.27	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for mangroves - primary	53.96	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for secondary forests	Varies depending on age (1-400 years) and forest type	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for annual cropland	21.16	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for permanent cropland	Varies depending on age (1-400 years)	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for paramos	31.13	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for very moist and rain forests – primary	49.5	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for moist forests - primary	48.27	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for dry forests – primary	56.47	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for mangroves - primary	6.95	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for palm forest - primary	5.97	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for secondary forests	Varies depending on	Sampling error	Truncated normal	Minimum value assumed to be 0

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
	age (1-400 years) and forest type			
Deadwood for grassland	8.28	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for very moist and rain forests – primary	10.05	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for moist forests - primary	8.01	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for dry forests – primary	22.73	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for mangroves - primary	0.97	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for palm forest - primary	0.96	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for secondary forests	Varies depending on age (1-400 years) and forest type	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for permanent cropland	Varies depending on age (1-400 years)	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in very moist and rain forests	5.03	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in moist forests	3.86	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in dry forests	3.47	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in mangroves	3.19	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in palm forests	4.26	Sampling error	Truncated normal	Minimum value assumed to be 0

Quantification of the uncertainty of the estimate of Emission Reductions

The country estimated the uncertainty of aggregated Emission Reductions based on Monte Carlo analysis. A total of 10,000 iterations were calculated for the cumulative emissions of reference and monitoring period[84].

		Total Emission Reductions*
A	**Median**	9,781,192
B	**Upper bound 90% CI** (Percentile 0.95)	16,347,028
C	**Lower bound 90% CI** (Percentile 0.05)	3,898,823
D	**Half Width Confidence Interval at 90% (B – C / 2)**	6,224,102
E	**Relative margin (D / A)**	63.6%
F	**Uncertainty discount**	12%

*Remove forest degradation if forest degradation has been estimated with proxy data.

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

In order to identify the relative contribution of each parameter to overall uncertainty, a sensitivity analysis was conducted in which the uncertainty of each parameter was selectively removed prior to running Monte Carlo simulations and combining uncertainties. As shown in the table below, the carbon stocks used to estimate emission factors for deforestation were by far the largest source of uncertainty. When this uncertainty source was removed, total uncertainty decreased by over 54%. The mapping error of new forests during the reference period, the error of the ratio of aboveground biomass to percent canopy cover, and changes in canopy cover in forests remaining forests during the monitoring period also had sizable impacts on uncertainty. When the uncertainty for each of these was removed, uncertainty decreased by 6.9%, 6.8%, and 6.2% respectively[85].

For certain sources of uncertainty, when selectively removed, the overall uncertainty of the emission reductions increased, albeit minimally. This can be explained by the fact that, when Monte Carlo simulations of multiple error sources are combined (say through multiplication), depending on the spread and distributions of the different sources of error, the final distribution may end up being narrower than when there are fewer sources combined. For example, when values at one end of the distribution are multiplied by values at the other end of another distribution, the resulting final values may end up nearer to the average.

Sensitivity analysis results

Error source selectively removed from uncertainty analyses	**Final % uncertainty of ERs**	**% change in total uncertainty of ERs**
Mapping error (AD) of deforestation in the reference period	63.3%	0.6% decrease
Mapping error (AD) of deforestation in the monitoring period	63.6%	0.1% increase
Carbon stocks used to estimate deforestation emission factors	29.2%	54.2% decrease
Mapping error (AD) of new forests in the reference period	59.3%	6.9% decrease
Mapping error (AD) of new forests in the monitoring period	64.0%	0.5% increase

[84] MC propagation analyses to estimate uncertainty of Emission Reductions can be found in the following link: https://drive.google.com/drive/folders/1sPjBD5kjd8JN6vXvLb6LaaTUjdRh8VtT?usp=sharing

[85] Sensitivity analyses of the uncertainty estimate for Emission Reductions can be found in the following link: https://drive.google.com/drive/folders/1sPjBD5kjd8JN6vXvLb6LaaTUjdRh8VtT?usp=sharing

Carbon stocks used to estimate enhancements in new forests	62.3%	2.1% decrease
Mapping error (AD) of forests remaining forests in the reference period	63.7%	0.2% increase
Mapping error (AD) of forests remaining forests in the monitoring period	63.9%	0.4% increase
Changes in canopy cover in forests remaining forests in the reference period	63.2%	0.6% decrease
Changes in canopy cover in forests remaining forests in the monitoring period	59.7%	6.2% decrease
Ratio of aboveground biomass (in t CO2e) to % canopy cover	59.3%	6.8% decrease
Carbon stocks used to estimate enhancements in forests remaining forests	63.7%	0.2% increase

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

FONAFIFO will distribute direct payments or monetary benefits from the Emissions Rection Purchase Agreements (ERPA) to forest landowners according to Benefit Sharing Plan. REDD+ Secretary has designed a Standards and Procedure Manual for the Emissions Reduction Payment Program, setting the technical and legal requirements to enter the ER Program and sign a CREF[86]. The landowners need a Forest Emissions Reduction Agreement (its acronym in Spanish is CREF) duly signed with FONAFIFO. The amount of compensation for forest owners is fixed and will depend on forest area contribution contributing to forest emissions reduction. A total of 635,000ha of natural forests and around 6,300 beneficiaries could participate in this mechanism. This area and beneficiaries would be added to active beneficiaries of the Payment Program Environmental Services (PPES) administered by FONAFIFO.

The ER-Program has experienced significant challenges in documenting ownership of emissions reduction. During the first phase of field visits for geolocation of properties, the potential participants showed no interest due to the possible payment (US$7/ha per year). This first estimate of emission reduction compensation resulted unattractive for the landowners compared with the current PES amount. The results of the first call for participation in the ER Program are not satisfactory. Until March 2021, the REDD Secretariat had achieved the documentation of 14% of the emission reductions.

The unregistered farms have the most significant potential to enter the ER Program due to the impossibility of participating in PPES. However, unregistered farms lack several legal requirements that are difficult to obtain. The REDD+ Secretariat is looking for options to engage unregistered farms since they represent a high ownership and farm size percentage. These represent an average area of 139 has per farm. Also, their participation becomes vital to achieve the area target within the ER Program and recognizing the effort these holders make in conservation. These groups' involvement was low because they guessed the unregistered farms are not suitable to enter conservation programs such as PPES. Also, the ER Program's promotion did not have the expected reaction in registered farms. The ER Program's payments and conditions were not attractive enough for the forest owners, especially for small farms. It is crucial to find a way to involve these small farm owners in the ER Program because they are the most prone to deforest their land.

Despite the overlay issues indicated above, the REDD+ Secretariat considers the country will reach the ex-ante estimation of transfer capacity of 55% of the total emission reductions. The Secretariat has completed the first version of the global geodatabase of non-overlapped forest land. Table 11 summarizes forest area by forest owners; 54,3% of forest land resulted eligible to participate in the Emission Reduction Program of Costa Rica. The Secretariat is still working on the overlay analysis and has not yet initiated the legal review of private owners' properties. If these studies reveal any issues, the total CREF area can be affected and lowered. Indigenous territory corresponds to the whole area available and outside the Payment for Environmental Payment contract's area. There are overlapping areas between indigenous territories and Protected Areas. REDD+ Secretariat is addressing this issue with the Minister of the Environment and the Director of SINAC, expecting to agree on the corresponding claim of emission reductions.

The recruitment process will be open until November 2021. The final figure of Forest Area included in the ER Program will be defined in December 2021. The REDD+ Secretary designed a recruitment plan with three options. This Plan seeks to recruit the most significant number of beneficiaries of the ER Program and ensure at least 55% of forest land in the country.

i. **Increasing CREF compensation**: The Ministry of Environment authorized the use of US$ 38.8 millions of REDD+ result-based payment granted to the country by the Green Climate Fund. This payment is compensation for reducing 14.08 million tons of carbon dioxide equivalent ($MtCO_2eq$) in emissions during

[86] A Draft of the Manual of Requirements and Procedures for the Emissions Reduction Program can be accessed at the following link https://docs.google.com/document/d/1ckHxhAomfagRVMfN9OH_86nOcx06VEIE/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true

the 2014-2015 period[87]. FONAFIFO will add these resources to the funds obtained from the Emission Reduction Purchase Agreement (ER-PA). With this combination of resources, the ER-Program will be able to pay US$ 18/ha per year during the seven years of the project.

ii. **Recruitment of former PES beneficiaries/applicants**: FONAFIFO's historic PES database consultation to identify potential beneficiaries who are no longer receiving PES or were not suitable to participate because they did not meet the priorities of the PPES. REDD Secretariat will contact the potential beneficiaries, phone calls or email to inform the ER Program and their participation.

iii. **Engagement of Forestry Organizations**: The principal forest owner organizations will be contacted, seeking their partners' involvement.

iv. **New call for participation**: a new call will be made to explain the ER Program and invite forest owners to participate.

Table 11. Forest area identified until December 2021 as eligible to participate in the Emission Reduction Program of Costa Rica.

	Forest Cover Owner Type		Non-overlapped Forest Cover area (ha)		Total (ha)	Emission Reductions (tCO_2)	Uncertainty buffer (12%)	Reversal Risk buffer (10%)	Number of FCPF ERs (tCO_2)
			With geographic support	Without geographic support					
Reported on Substantial Volume of ER	1	CREF requests (with property deed)	24,035.4		24,035.4	80,864.6	9,703.8	7,116.1	**64,044.8**
	2	Indigenous Territores	185,321.4		185,321.4	623,495.9	74,819.5	54,867.6	**493,808.8**
	3	FONAFIFO PES Program	338,089.3	11,989.5	350,078.7	1,177,805.9	141,336.7	103,646.9	**932,822.2**
		Biodiversirty Fund	7,264.4		7,264.4	24,440.2	2,932.8	2,150.7	**19,356.7**
	4	State Natural Heritage-SINAC [1; 2]	665,278.9		665,278.9	2,238,266.3	268,592.0	196,967.4	**1,772,706.9**
		Subtotal	**1,219,989.3**	**11,989.5**	**1,231,978.7**	**4,144,873**	**497,385**	**364,749**	**3,282,739**
Non-reported areas on Substantial Volumen of ERs. Areas under legal analysis.	3	FONAFIFO PES Program[1]	120,617.2		120,617.2	405,804.9	48,696.6	35,710.8	321,397.5
	4	State Natural Heritage - JAPDEVA	40,546.1		40,546.1	136,413.3	16,369.6	12,004.4	108,039.3
		State Natural Heritage-Local Governments	226.5		226.5	761.9	91.4	67.0	603.4
		SNH-Other State Institutions	6,067.3		6,067.3	20,412.8	2,449.5	1,796.3	16,166.9
	5	Forest cover in inalienable areas	35,814.2		35,814.2	120,493.5	14,459.2	10,603.4	95,430.8
	6	Forest cover in Protected Wilderness Areas (outside National Parks, Biological Reserves, and National Monuments)[2]	319,384.6		319,384.6	1,074,538.5	128,944.6	94,559.4	851,034.5
	7	Forest Cover in Overlay Analysis	1,546.9		1,546.9	5,204.4	624.5	458.0	4,121.9
		Subtotal	**524,202.7**	**0.0**	**524,202.7**	**1,763,629.1**	**211,635.5**	**155,199.4**	**1,396,794.3**
A.Subtotal of forest cover area with documented ownership			**1,231,978.7**						

[87] FP144 Costa Rica REDD-plus Results-Based Payments for 2014 and 2015 https://www.greenclimate.fund/project/fp144

B.Subtotal of forest cover area with undocumented ownership	1,884,856.3	
C.Total area of forest cover in 2019	3,116,835.0	
D.Percentage of ERs for which the ability to transfer Title to ERs is clear or uncontested (A/C)	39.53%	

[1] There are 120,617.2 ha of forest cover under review that may affect the State Natural Heritage-SINAC area and forest cover outside of National Parks, Biological Reserves, and National Monuments

[2] PES contract areas for the 2007-2011 period located in Protected Wilderness Areas are subtracted

6.2 Implementation and operation of Program and Projects Data Management System

The country has decided to maintain its own comprehensive national REDD+ Program and Projects Data Management System (MF I.37.1). Costa Rica Emission Reduction Program´s data management system is part of the National System of Climate Change Metrics of Costa Rica (SINAMECC). SINAMEC is Costa Rica's official platform to coordinate climate information in the country (Figure 3). The system serves to track national climate change policy progress, enable data-driven decision-making, and facilitate reporting under national and international commitments. SINAMECC was officially established in 2018 by Executive Decree No. 41127-MINAE[88]. The system operates as a sub-module of the National Environmental Information System (SINIA), linked to the National Statistical System (SEN). Climate Change Directorate (DCC) of the Ministry of Environment and Energy (MINAE) coordinates SINAMECC.)[89]. This system also has the SINAMECC Committee made up of the National Meteorological Institute (IMN), the Secretariat for Sector Planning for the Environment, Energy, Seas and Territorial Planning (SEPLASA), the National Center for Geo-environmental Information (CENIGA), and the National Institute of Statistics and Censuses (INEC)[90].

SIMAMECC has three modules: i. Mitigation, ii. Adaptation, and iii. Climate Finance. The mitigation module aims to register and measure climate change mitigation actions in Costa Rica with transparency. A mitigation action is an initiative that reduces greenhouse gas emissions or increases carbon dioxide removals, such as sector initiatives - NAMAs. Also, it includes private projects within the Country Program for C-neutrality and actions derived from public policy associated with sectoral development plans. For transparency purposes, as far as possible, all actions - small or large in scale and impact - must be part of SINAMECC, which seeks to ensure that the effects of the mitigation action are reflected in the national inventory of greenhouse gases.

The country is implementing the Mitigation Action Registry. Mitigation actions in Costa Rica have multiple metrics and different baselines; this prevents aggregation and definition of collective progress on reducing emissions at the national level. Therefore, the Mitigation Action Registry will document the initiatives together with a procedure for harmonization with the National Greenhouse gas inventory[91].

The REDD+ Secretariat has completed the documentation forms required by the SINAMECC Mitigation Actions Registry for the Costa Rica Emission Reduction Program (PRE)[92]. This template includes the following information, among others (MF I.37.2): i. Initiative Name, ii. Entity promoting the initiative (name, business name, representative,

[88] Decree 41127-MINAE can be accessed at the following link
http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?nValor1=1&nValor2=86584
[89] Decree 35669-MINAE can be accessed at the following link
http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?nValor1=1&nValor2=66973
[90] http://sinamecc.go.cr/acerca-de
[91] Concept note of Design and testing of a cross-sectorial Measurement, Reporting, Verification and Registry framework for Costa Rica's National Climate Change Metrics System
http://sinamecc.go.cr/biblioteca-sinamecc/conceptoSinamecc
[92] The documentation form completed for the ER-P can be accessed at the following link
https://docs.google.com/spreadsheets/d/1ltS_8NvZeF79ZfqAVrTVcltq2_UB88GB/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true

and information contact.), iii. The scale of the mitigation action, iv. Description, REDD + type activity, and carbon pools considered, v. Methodological framework or Standard, vi. Project Life Cycle (Credit Period), vii. Reference Level used; viii. Existence of a purchase-sale contract for Reduction of emissions, and ix. Ex Ante Estimation of Emissions Reduction. The REDD+ Secretariat will document in the Costa Rica Emission Reduction Program´s data management system the title-right owner and beneficiaries' information, geographic limits of the properties and forest area included in the PRE.

Figure 4 shows the line diagram for the operation of the ER-Program Data Management System. Table 12 provides details on the users, analysts, reviewers, and approvals functions of the ER-Program Data Management System. The REDD+ Secretariat, together with the FONAFIFO Legal Department, has prepared a manual of requirements and procedures for the Emissions Reduction Program. The manual details the beneficiary's approval procedures in PRE, including decision rules for overlap cases between landowners and the legal requirements, both for private owners and the natural heritage of the state and indigenous territories. Finally, it indicates the general terms of the session of the rights and the payment of the RE[93].

The REDD+ Secretariat is implementing the ER-Program Data Management System. The following tasks have been completed or are in progress:

- *Calls for CREF beneficiaries*: The REDD+ Secretary of Costa Rica and FONAFIFO have made two calls for participating in the Emissions Reduction Program (PRE) and later to sign Emissions Reduction Contracts (CREF). The first was in October 2020, and the second was in August 2021. The REDD+ Secretary of Costa Rica and FONAFIFO called for the first time. FONAFIFO invited forest owners to express their interest in participating and learn about the Program by filling out a form[94] on FONAFIFO's website[95]. Farm owners with forests, natural regeneration, forest management (primary or secondary), or forest plantations can participate in the CREF mechanism. FONAFIFO promoted the campaign in different media such as national circulation newspapers, Facebook, website, and individual invitations to several organizations or relevant stakeholders. REDD+ Secretariat is building a database with all the applications.

- *Analysis of ER owners*: As part of the ER Program's entry process and to demonstrate ownership of emission reductions, REDD Secretariat is building a geospatial database with the potential ER Program beneficiaries, including private forest owners, Indigenous peoples, SINAC, FONAFIFO, and other institutions administering State Natural Heritage. The REDD+ Secretariat has made a preliminary time/spatial overlay analysis considering i. Overdue Payment for Environmental Services (PES) contracts and rejected applications, ii. Geodatabase of forest lands owned by the State, iv. Geodatabase of active PES contracts, v. Geodatabase of forests lands in Indigenous Territories, vi. Geodatabase of forest lands supported by the Biodiversity Fund, and vii. Geodatabase of the first call of CREF beneficiaries. This analysis identified landowners' non-overlapped forest areas with CREF applications or expired agreements and applications that have not entered the Payment program for environmental services (PPES).

- *Property geolocation analysis*: The database allows REDD+ Secretariat to locate overlayed areas between private owners. Also, to determine if the overlaying is due to location errors in the cadastre plan. The Geospatial Analyst of The REDD Secretariat is preparing CREF non-overlapped maps for each application

[93] A Draft of the Manual of Requirements and Procedures for the Emissions Reduction Program can be accessed at the following link https://docs.google.com/document/d/1ckHxhAomfagRVMfN9OH_86nOcx06VElE/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true

[94] Application to Join the CREF Project https://forms.office.com/Pages/ResponsePage.aspx?id=ytnVe7YiPUK3Aloh1bsHR3mtNt1gTYhOgux9YcGhPN9UNkRVT1NFMDZES0FMR0dEVTRXSTMwQ0kzWC4u

[95] www.ganacontubosque.com

received during the calls. The procedure for the overlay analysis is in the manual of requirements and procedures for the Emissions Reduction Program[96].

- *Field visits*: The Field Analyst of the REDD+ Secretary visits the properties of the potential beneficiaries to identify and resolve any location issue. The Secretary has visited eighty locations with applications to the ER Program. Property accessibility has resulted in a problem. Remote properties usually do not maintain clear boundaries, complicating the cadastre plan's verification and increasing recruitment costs.

- *Legal analysis*: After the overlay issues have been solved, the REDD Secretary does a legal analysis and then proceeds with the signature of the CREF.

The REDD+ Secretariat, with the support of the World Bank, is building a repository system for Costa Rica REDD+ information. This repository will be hosted in the servers of FONAFIFO and will include the publication of the Database of the Project Data Management System. In this way, the REDD+ Programs and Projects Data Management System will be available to the public via the internet in the Spanish language.

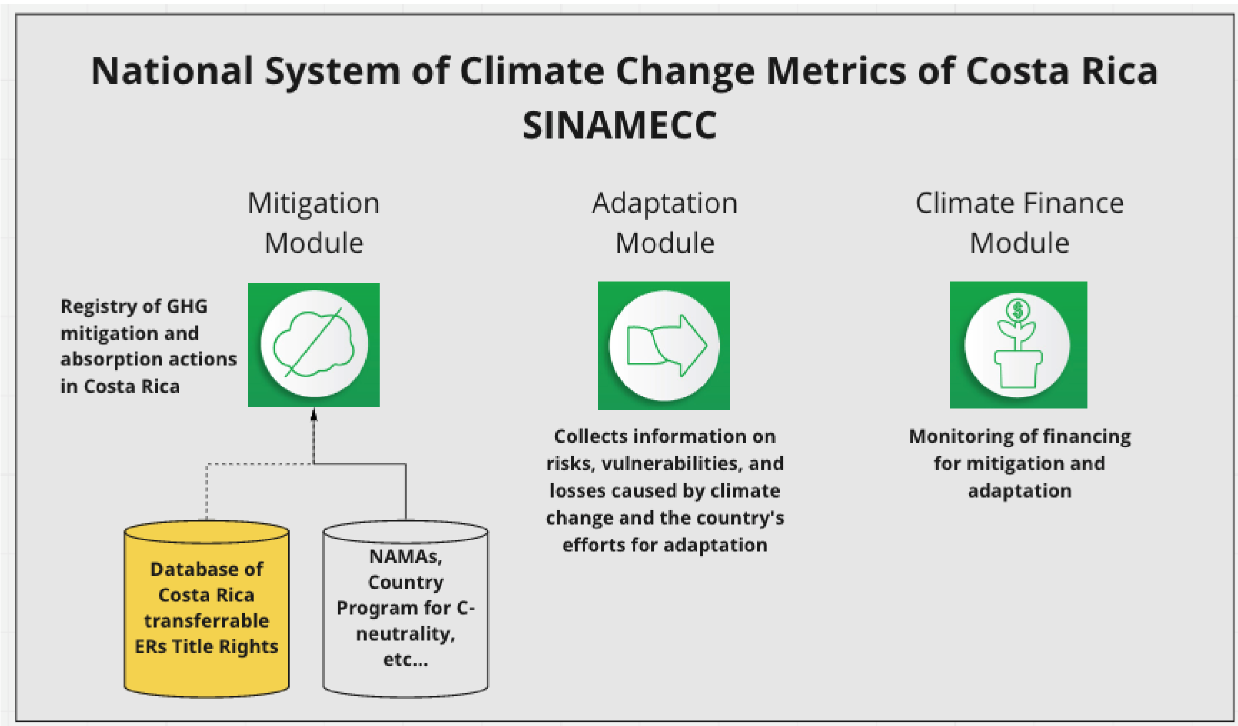


Figure 3: National System of Climate Change Metrics of Costa Rica (SINAMECC). Costa Rica Emission Reduction Program´s data management system is part of the SINAMEC. This system is Costa Rica's official platform to coordinate climate information in the country.

[96] A Draft of the Manual of Requirements and Procedures for the Emissions Reduction Program can be accessed at the following link https://docs.google.com/document/d/1ckHxhAomfagRVMfN9OH_86nOcx06VEIE/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true

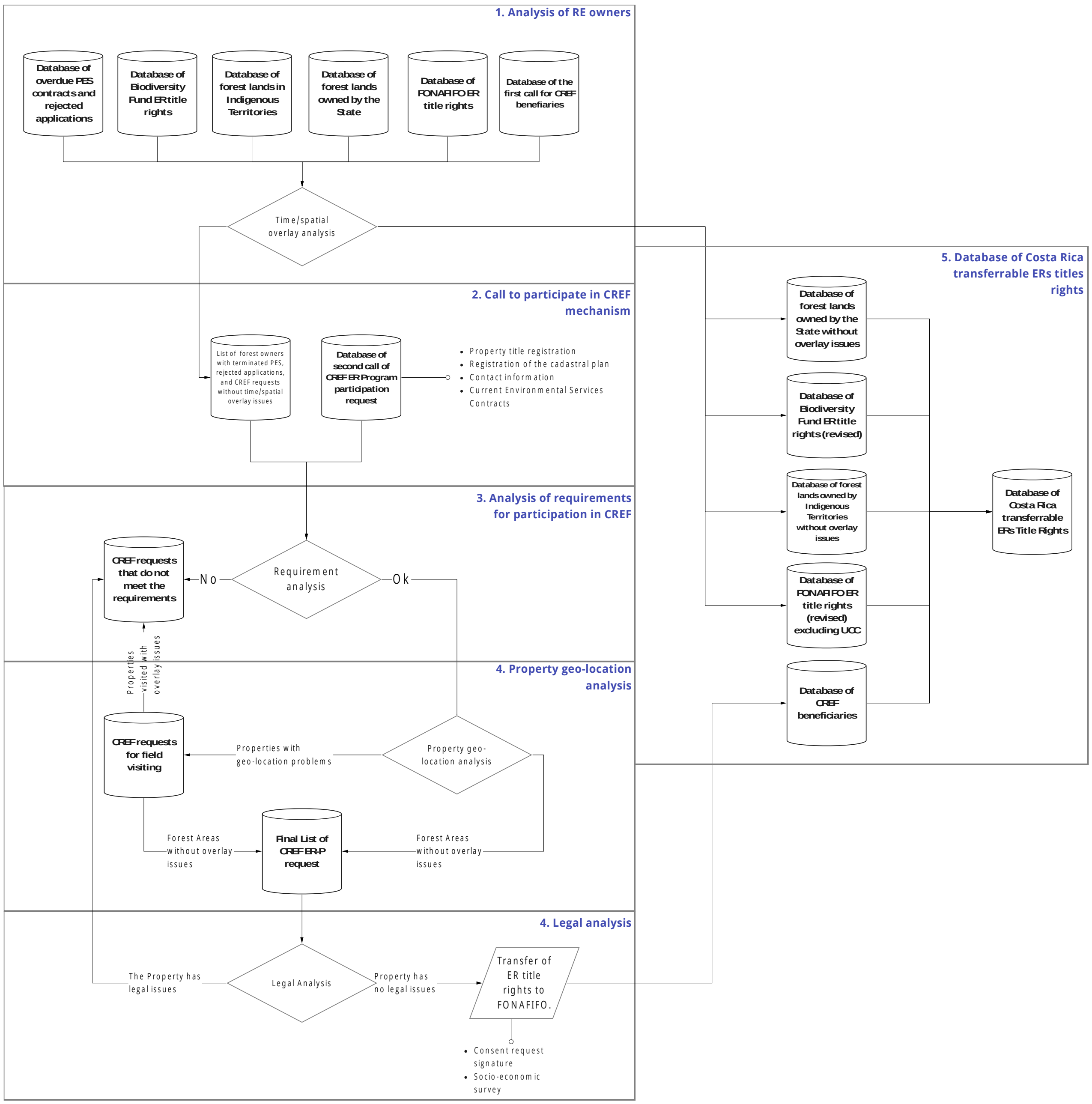


Figure 4: Line diagram for the building process of Costa Rica ER-Program Data Management Syste

Table 12: Functions of the ER-Program Data Management System

Registration process phases	User / Analyst	Reviewer	Approval	Issuance of Opinion
Receipt of CREF requests	Landowner with forest cover	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	Approval of the closing report for the receipt of CREF applications
Receipt Payment for Environmental Services Program geodatabase.	FONAFIFO	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	Approval of database reception report
Receipt of the State Natural Heritage geodatabase	SINAC	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	Approval of database reception report
Receipt of Biodiversity Fund geodatabase	FUNBAN	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	Approval of database reception report
Preparation of the Indigenous Territories geodatabase	Geospatial Analyst (REDD+ Secretariat)	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	Approval of database reception report
CREF Requirements Analysis	Requirements Analyst (REDD+ Secretariat)	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	Requirements review report approval
Spatial overlap analysis between ER´s owners	Geospatial Analyst (REDD+ Secretariat)	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	CREF effective area maps
Geolocation field review of properties.	Field Analyst (Forestry Engineer - REDD+ Secretariat)	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	Corrected CREF effective area map
Legal Analysis	CREF recruitment officer (REDD+ Secretariat)	Legal Analyst (FONAFIFO)	Head of FONAFIFO´s Legal Department	RE title-right contract
Registry ER title-rights	Geospatial Analyst (REDD+ Secretariat)	CREF recruitment officer (REDD+ Secretariat)	Head of REDD + Secretariat	Record ID of the property in the database.

6.3 Implementation and operation of ER transaction registry

The Government of Costa Rica has decided to use the FCPF ER Transaction Registry in conjunction with its own national registry, which is currently being developed as part of the National Climate Change Metrics System (Sistema Nacional de Métrica de Cambio Climático, SINAMECC). As part of the measures to avoid double counting of ERs generated from Costa Rica FCPF ER Program in the national transaction registry and the FCPF ER Transaction Registry, once the national registry is operational the Government of Costa Rica will only recognize, including for purposes of reporting to the Trustee, authorization and/or corresponding adjustments units that are duly registered in the Costa Rican national registry. Both Parties will take all reasonable efforts to ensure that the Costa Rican national registry component of SINAMECC and the FCPF ER Transaction Registry will incorporate all features necessary to enable communication and operational compatibility between the systems.

>>

6.4 ERs transferred to other entities or other schemes

No ERs from the ER Program were sold, assigned, or used by any other entity for sale, public relations, compliance, or any other purpose, including ERs that have been set aside to meet Reversal management requirements under other GHG accounting 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)

Costa Rica uses the Reversal Risk assessment tool to determine the Reversal Risk Set-Aside Percentages for each of them. These risk factors, as specified in the ER-PD, are:

1. Default risk set by the FCPF (10%)
2. Lack of broad and sustained stakeholder support (low, 0%)
3. Lack of institutional capacities and/or ineffective vertical/cross sectoral coordination (low, 0%)
4. Lack of long-term effectiveness in addressing underlying drivers (low, 0%)
5. Exposure and vulnerability to natural disturbances (low, 0%)

This analysis revealed that the overall risk of reversals in the country is 10%. Costa Rica's circumstances have not changed and thus this risk of reversals is maintained during the monitoring period (see section 7.3 below). Costa Rica manages Reversal Risks through the use of an ER Program CF Buffer; a buffer reserve account has been established for this purpose in an appropriate ER Transaction Registry, following FCPF's registry conditions.

As shown in section 4, there have not been reversals during the reporting period, and Costa Rica reduced net emissions by 10.486.289 t CO_2e during the reporting period.

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]**		
G.	**Cumulative quantity of Total ERs estimated including the current reporting period (as an aggregate of ERs accumulated since beginning of the ERPA) [C – F]**		
H.	**Cumulative quantity of Total ERs estimated for prior reporting periods (as an aggregate of ERs accumulated since beginning of the ERPA)**	*from previous ER Monitoring Reports*	
I.	**[G – H], negative number indicates Reversals**		
If I. above is negative and reversals have occurred complete the following:			
J.	**Amount of ERs that have been previously transferred to the Carbon Fund, as Contract ERs and Additional ERs**		
H.	**Quantity of Buffer ERs to be canceled from the Reversal Buffer account [J / H × (H – G)]**		

7.3 Reversal risk assessment

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk	*N/A*	**10%**	*N/A*	*10%*
Lack of broad and sustained stakeholder support	Land tenure conflicts, carbon rights conflicts, insufficient stakeholder consultation. Costa Rica is undertaking REDD+ readiness activities targeting governance issues, such as the land tenure and carbon rights conflict that affect the forest land owned by indigenous people in the country. These activities entail	**10%**	*Reversal Risk is considered low: 10% discount*	*0%*

	adopting improved governance structures and processes[97] that aim to eliminate the conflict and abate the risk it poses, thereby enhancing the long-term effectiveness of the REDD+ program. In addition, the mechanism to resolve carbon right disputes is defined in the REDD+ Decree No. 40464, which states the mechanisms of carbon trading and REDD+ Strategy financing. The strategies to reduce deforestation have been developed in consultation with groups with land tenure/rights conflicts in the country through FONAFIFO's safeguards system, i.e. indigenous peoples and agroforestry producers. Finally, REDD+ Secretary is taking action to minimize the probability of a reversal due to overlay issues. The selection process of CREF beneficiaries applications is based on an overlay analysis of a global geodatabase of ER's owners. CREF mechanism will include only non-overlapped forest land (See section 6.2).			
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	Insufficient experience implementing programs and policies, lack of cross-sectoral cooperation and between gov. levels. FONAFIFO is the focal point for the REDD+ program in Costa Rica, with several other government agencies playing supporting roles across sectors and government levels. FONAFIFO also defined the reference level during the REDD+ readiness phase, runs a Service Comptroller, and manages both the Feedback and Grievance Redress Mechanism (FGRM) and the ongoing National REDD+ Consultation process. In addition, the national REDD+ program proposes to expand the PES (Payment for Ecosystem Services) program, which has been ongoing since 1997. The PES program regulated through FONAFIFO evidences Costa Rica's capacity to successfully coordinate and implement forest protection programs at the national scale.	**10%**	*Reversal Risk is considered low: 10% discount*	*0%*
Lack of long-term effectiveness in addressing underlying drivers	Limited decoupling of deforestation and degradation from economic activities, lack of laws and regulations conductive to REDD+ objectives. Costa Rica has developed a REDD+ Strategy Implementation Plan[98] that defines priority actions under the Emissions Reduction Program. One of these priority actions entails promoting deforestation-free supply chains of commodities and subsistence activities driving deforestation in the country. Additional actions to address drivers of deforestation and degradation have been taken since the reference period, such as the inclusion of representative agents of deforestation (i.e. crop and livestock farmers) or degradation (i.e. illegal selective loggers) in stakeholder consultations and the benefit sharing plan. This has resulted in emission reductions and/or removals are listed in Section 7 of this monitoring report.	**5%**	*Reversal Risk is considered low: 5% discount*	*0%*
Exposure and vulnerability to natural disturbances	Exposure and vulnerability to natural disturbances and disasters, limited capacity and/or experience in preventing them.	**5%**	*Reversal Risk is considered*	*0%*

[97] Rodríguez Zúñiga and Arce Benavides, 2017. Marco de Gestión Ambiental y Social (MGAS) para el Plan de Implementación de la Estrategia Nacional REDD+ de Costa Rica. FONAFIFO, MINAE. 95 pp.
[98] Plan de Implementación de la Estrategia Nacional REDD+ Costa Rica. 2017. Versión 7. 57 pp.

	Costa Rica considers the following natural risks affecting its forest lands: • Low-intensity natural disturbances are frequent and cause small and diffuse impacts that cannot be easily differentiated from the impacts caused by anthropogenic factors. The emissions caused by the these disturbances are measured through the degradation accounting approach but excluded from the degradation reference level and will be excluded in future measurement reports of the Program results, thereby posing no risk of reversals. • The high-intensity natural disturbances that can occasionally result in significant impact occur at a lower frequency. Examples of these disturbances are volcanic eruptions, earthquakes/tsunamis and extreme climate events. Most of the impact areas of volcanic eruptions are easily identifiable in the Landsat images and can be clearly separated from the impacts caused by anthropogenic activities. For this reason, the impacts on forests caused by these volcanic events have been excluded from the reference level, although they are transparently reported. The same will be done in future reports on the measurement of the program results. Since these areas have been excluded, their risk of reversals in Costa Rica is zero. Geological and extreme weather risks, on the other hand, are low.		*low: 5% discount*	
		Total reversal risk set-aside percentage		*10%*
		Total reversal risk set-aside percentage from ER-PD or previous monitoring report (whichever is more recent)		*10%*

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

A.	**Emission Reductions during the Reporting period (tCO_2-e)**	*from section 4.3*	**10,486,289**
B.	**If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)**		0
C.	**Number of Emission Reductions estimated using measurement approaches (A-B)**		10,486,289
D.	**Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested**	*from section 6.1*	39.53%
E.	**ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes**	*from section 6.4*	0
F.	**Total ERs (B+C)*D-E**		4,145,230
G.	**Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period**	*from section 5.2*	12%
H.	**Quantity of ERs to be allocated to the Uncertainty Reversal Buffer (0.15*B/A*F)+(G*C/A*F)**		497,427
I.	**Total reversal risk set-aside percentage applied to the ER program**	*from section 7.3*	10%
J.	**Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)**		182,390
K.	**Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*5%**		182,390

L.	**Number of FCPF ERs (F- H – J – K)**	**3,283,023**[99]

[99] The number of FCPF ERs corresponds to the Substantial Volume reported by the Country as part of the conditions of effectiveness of the ERPA. Additional ERs are under legal analysis, and the country will present an updated volume of clear and uncontested ER on June 30th, 2022

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

This annex is a brief overview based on the more detailed information on the implementation of safeguards in the Safeguards Monitoring Report for the Retroactive Period for January 2018-December 2019, hereby referred to as the Retroactive Report 2018-2019. The objective of the report is to identify and determine whether the following ER Program measures and actions were executed in a manner consistent with national environmental and social legislation, institutional guidelines, and procedures identified in the Environmental and Social Management Framework (ESMF) during the retroactive evaluation period between 2018-2019:

- 2.1.1 Promote the generation and implementation of forest fire prevention campaigns
- 2.1.2. Monitoring and promotion of volunteer forest fire departments
- 2.1.3. Strengthening of the Forest Fire Control Program
- 2.2.1. Strengthening of the Illegal Logging Control Program
- 2.2.2. Reactivation of the Natural Resources Oversight Committees (*Comités de Vigilancia de los Recursos Naturales*, COVIRENAS)
- 2.3.1. Administration and management of Wildlife Protected Areas (*Áreas Silvestres Protegidas*, ASPs)
- 3.1.2. Expansion and improvement of financial mechanisms to favor natural regeneration

Given the annex refers to the period between January 2018-December 2019, some sections of the template do not apply entirely to this retroactive period because the ER Program was in its nascent stages and the ESMF had just been finalized. Nevertheless, the sections have been completed to the extent possible.

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

The implementation of safeguards within the scope of the Emissions Reduction (ER) Program complies with World Bank social and environmental safeguards that are aligned with UNFCCC guidance related to REDD+.

The design and implementation of the ER Program has been developed in accordance with the **ESMF**, which was prepared based on applicable national environmental and social legislation, national and institutional procedures and in accordance with the World Bank's environmental and social operational policies. It identifies and assesses the potential environmental and social risks and impacts resulting from the measures proposed, incorporating the findings of the **Strategic Environmental and Social Assessment** (SESA) conducted in the initial preparation phases. The Retroactive Report 2018-2019 considers the following Operational Policies (OP) and their compliance within the framework of the ER Program in the activities listed above: Environmental Assessment (OP 4.01), Natural Habitats (OP 4.04), Pest Control (OP 4.09), Indigenous Peoples (OP 4.10), Involuntary Resettlement (OP 4.12) and Forests (OP 4.36). In the context of Costa Rica's ERPA, no environmental and social plans were developed because they were not required by activities per the ESMF and national legislation. However, environmental and social measures were implemented. Section 2.2.1 of this annex focuses only on the risks and main mitigation measures identified in the report. During the retroactive period, the ESMF had been revised to incorporate comments issued by the World Bank and was finalized. The ESMF has been published on the country's REDD+ page and transferred through the Secretariat's REDD+ liaisons to the corresponding institutions and virtual meetings have been held with officials to socialize the document. Training on safeguards have been developed, but implemented exclusively to the departments involved in reporting and need to be extended further.

Effectively addressing the issues and complaints of individuals or groups affected by project activities is also an essential component of operational risk management and FCPF requirements. Grievance Redress Mechanisms are a way to prevent and resolve community concerns, reduce risk and support processes that create positive social change. For this purpose, Costa Rica has an **Information, Feedback and Non-conformities Mechanism** (*Mecanismo de Información, Retroalimentación e Inconformidades*, MIRI), which is detailed in Section 2.2.4 of this annex.

Considerations for Indigenous Peoples featured prominently in each of the activities and their corresponding measures for compliance. In the framework of building the National REDD+ Strategy, the Government of Costa Rica proposed a national dialogue that began in 2012, starting with the SESA workshop, where leaders from the country's 24 Indigenous groups participated and helped define the agenda. A national dialogue took place over 3 nation-wide meetings and the participation of 19 Indigenous territories. This culminated in the approval of a **National Indigenous Consultation Plan** (*Plan Nacional de Consulta Indígena*) and the appointment of delegates to the REDD+ Executive Committee. The plan developed an entire methodology for implementing consultation in three phases: information, pre-consultation and consultation in Indigenous territories. Five key themes for consultation were prioritized by the Indigenous territories: (i) land titling, (ii) Indigenous Payment for Environmental Services (PES), (iii) forests and cosmovision, (iv) Indigenous territories and ASPs and (v) monitoring and participation. The implementation of this methodology prompted the recognition of the Indigenous Consultation Unit of the Ministry of Justice and Peace (*Unidad de Consulta Indígena del Ministerio de Justicia y Paz*, MJP), through the official letter DNRAC-UTCI02-2021 stating "the process carried out by the REDD+ Secretariat in conjunction with the Indigenous territories since 2008, has complied with the standards (principles, criteria and procedures) of the **General Consultation Mechanism for Indigenous Peoples** (*Mecanismo General de Consulta a Pueblos Indígenas*, MGCPI), as it has been carried out with broad participation of Indigenous peoples in a free, prior and informed manner, through appropriate procedures and through their representative institutions (Art 1, Executive Decree 40932-MP-MJP)". Moreover, the REDD+ Secretariat respected and promoted steps to ensure the participation of Indigenous Peoples according to the **Indigenous Peoples Planning Framework** (*Marco de Planificación para Pueblos Indígenas*, MPPI) included in the ESMF. The activities related to Indigenous Peoples must continue in compliance and procedure with the MGCPI, which has been formalized by the Costa Rican government, so that the processes for the construction of the **Forest and Territorial Environmental Plans** (*Planes Ambientales Forestales y Territoriales*, PAFT) consider the existing internal structures recognized by the communities, as well as the development of the issues and concepts addressed during the consultation of the National REDD+ Strategy, in order to achieve compliance with the agreements and respect their safeguards.

In addition, SINAC was supported by the resources of the Forest Carbon Partnership Facility (FCPF) grant and developed an **Indigenous Peoples Chapter for the update of the National Forestry Development Plan** (*Capítulo Indígena del Plan Nacional de Desarrollo Forestal*) in 2019. With the participation of 114 Indigenous leaders over 9 workshops, strategic axes were identified for the implementation of the program. Working with Indigenous communities allowed for the recognition of traditional uses of the ecosystems through a process of free, prior and informed consent (FPIC) and helped strengthen and/or establish the necessary alliances to work jointly and made it possible to identify social and economic linkages that will generate culturally appropriate and inclusive benefits for local, Indigenous communities.

Inclusion also extended to gender considerations. A **Gender Action Plan** was developed in 2019 and mainstreamed into the policies, actions and measures of the National REDD+ Strategy. This was the first Gender Action Plan developed by the country on climate issues and marked a clear path based on participatory "bottom-up" inputs validated and proposed in consultation with gender experts, civil society organizations, groups of Indigenous women and rural smallholder forest producers to lay out a clear path for providing financial resources, technical assistance and monitoring to empower and support women as part of the solution for protecting Costa Rican forests. The Gender Action Plan has helped shape the ERPA, with the creation of an Inclusive Fund for Sustainable Development to support activities unrelated to land, more focus on promoting mechanisms to finance activities within productive units, and an award that addresses structural gaps within units and is oriented to support them by providing options for recognition and promoting linkages for their products.

Another key requirement for REDD+ is a **Safeguards Information System** (SIS) for providing publicly available information on how safeguards are being addressed and respected. The SIS is located within the National Geo-environmental Information Center (*Centro Nacional de Información Geo-ambiental,* CENIGA), specifically in the National Environmental Information System (*Sistema Nacional de Información de Ambiental,* SINIA), which is in an advanced stage of construction but was not yet operational during the retroactive period. It has not been taken into account for the current reporting period because the system still requires a process to finalize the indicators that comply with the Cancun Safeguards as well as other necessary information for the National REDD+ Strategy in subsequent reporting periods. More details are available at http://ceniga.go.cr/sistemas-de-informacion-ambiental/.

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.

The main institutions responsible for the implementation of the ESMF and the environmental and social management procedures and instruments are the National Forest Financing Fund (*Fondo Nacional de Financiamiento Forestal*, FONAFIFO) and the National System of Conservation Areas (*Sistema Nacional de Áreas de Conservación*, SINAC) through the REDD+ Executive Secretariat. A detailed analysis of the institutions involved and their respective functions, technical skills, responsibilities, human and financial resources is available in Section VII of the Retroactive Report 2018-2019, summarized below for the purpose of this annex.

Institutional Responsibilities and Decision Procedures required per the ESMF

REDD+ Executive Secretariat: The REDD+ Executive Secretariat is responsible for directing, monitoring and coordinating the continued application of the socio-environmental management instruments according to national regulations and compliance with the World Bank's environmental and social operational policies. With respect to the ESMF, the REDD+ Secretariat is primarily responsible for ensuring compliance with the policy frameworks for involuntary resettlement, Indigenous Peoples Planning Frameworks, procedural standards, mechanisms and mitigation measures for environmental and social risks and impacts, monitoring of the MIRI, national and international reports on compliance with safeguards and operational policies, operation and monitoring of the SIS, in coordination with the main implementing entities with respect to the provisions of the ESMF, as well as preparing regular monitoring and evaluation reports.

Safeguards and ESMF Unit: This unit under the REDD+ Executive Secretariat will be in charge of reviewing, sharing and submitting annual monitoring reports for validation and managing all the processes, information and documents associated with the National REDD+ Strategy for compliance with ESMF requirements. In addition, it will be responsible for reports to be submitted to the World Bank team in the framework of compliance with the established commitments.

Ministry of Environment and Energy (*Ministerio del Ambiente y Energía*, MINAE): Although it does not have a direct participation in the implementation of activities of the National REDD+ Strategy or in the ESMF, as the entity responsible for providing the highest political orientation in environmental and energy matters in the country, MINAE does have a political responsibility in the supervision and fulfillment of the commitments assumed by the country. In this sense it will ensure the appropriate participation of all administrative units of MINAE involved, as well as in the coordination of actions with other ministries, autonomous institutions and any other government entity outside its scope.

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

Since its legal creation, the REDD+ Executive Secretariat has consisted of two SINAC representatives and three FONAFIFO representatives who have participated in the process up to the signing of the Emissions Reductions Purchase Agreement (ERPA) and supported the development of the Retroactive Report 2018-2019. Although the Safeguards and ESMF Unit was not yet established during the reporting period, it was possible to implement the

ESMF procedures through the professional staff of the involved institutions, SINAC and FONAFIFO. The implementation and monitoring functions of the ESMF were assumed as part of the general activities at the departmental level. Each of the implemented actions during the retroactive period, which had been executed in a manner consistent with the procedures and regulations established in the ESMF regarding the management of potential environmental and social risks and impacts, were supervised by corresponding departments in SINAC and FONAFIFO. Table A1.1 lists the institutions and their respective internal departments that are linked to the implementation and reporting of each measure.

Table A1.1 Institutions and departments responsible for each ER Program measure and action

Implemented Actions	**Institution Responsible**	**Department linked to the Implemented Actions**
2.1.1 Promote the generation and implementation of forest fire prevention campaigns	SINAC	Department of Protection, Prevention and Control (*Departamento de Protección, Prevención, y Control*, PPC)
2.1.2. Monitoring and promotion of volunteer forest fire departments	SINAC	PPC
2.1.3. Strengthening of the Forest Fire Control Program	SINAC	PPC
2.2.1. Strengthening of the Illegal Logging Control Program	SINAC	PPC
2.2.2. Reactivation of COVIRENAS	SINAC	Department of Public Participation and Governance (*Departamento de Participación Ciudadana y Gobernanza*, PCG)
2.3.1. Administration and management of ASPs	SINAC	Department of Conservation and Sustainable Use of Biodiversity and Ecosystem Services (*Departamento de Conservación y Uso Sostenible de la Biodiversidad y Servicios Ecosistémicos*, CUSBSE)
3.1.2. Expansion and improvement of financial mechanisms to favor natural regeneration	FONAFIFO	- Directorate of Environmental Services - Department of Control and Monitoring - Department of PES Management

Within the Secretariat, additional personnel have been proposed for the operation of the ER Program with the results-based payments defined in the ERPA and as established in the Benefit Sharing Plan. The professional reinforcement will consist of three environmental and social area specialists to support the institutional staff appointed within the Secretariat to address social, environmental and Indigenous issues during the implementation of the ER Program and to facilitate the internal coordination between the staff of the different institutional departments. Once the first disbursement of ERPA resources is received and these personnel are hired, the Safeguards and ESMF Unit will be established to support safeguards implementation and reporting in the next monitoring period and will be responsible for the implementation, follow-up and monitoring of the ESMF.

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.

REDD+ Secretariat:

The main institutions responsible for the implementation of the ESMF and the environmental and social management procedures and instruments in the framework of the National REDD+ Strategy are FONAFIFO and SINAC, through the REDD+ Executive Secretariat. The REDD+ Secretariat has been firmly established through Executive Decree No. 40464-MINAE in 2017, which defined its structure and main functions as the entity responsible for overall implementation and for ensuring compliance with the World Bank's safeguards and operational policies. Both institutions involved in implementation have been clear about their roles and have the appropriate official operating procedures granted by law that have allowed them to comply to date.

During the 2018-2019 reporting period, in addition to its staff, the REDD+ Secretariat hired the following personnel with grant resources to provide targeted support:

- An Indigenous advisor to support the development of the activities with respect to FPIC and the coordination of the Indigenous consultation.
- A forestry professional to coordinate emission reductions monitoring processes for the Strategy and the ER Program.
- A lawyer to review and advice ERPA documentation, review Forest Emissions Reductions Contracts (*Contratos de Reducción de Emisiones Forestales*, CREF) contract proposals, among others.
- Two professionals, one in social planning and the other in anthropology, to prepare the first draft of the Retroactive Report 2018-2019.

In addition, the staff of the institutions that make up the REDD+ Executive Secretariat, FONAFIFO and SINAC, were assigned technical departmental tasks related to the actions implemented during the retroactive period, described previously in Table A1.1. The information on the EMSF was disseminated to these staff via direct communication and meetings on virtual platforms to coordinate information and discuss issues. FONAFIFO and SINAC manage records of the activities of the ER Program in their administrative units for the specific measures for which they are responsible. Once resources from results-based payments are available, in addition to the establishment of a Safeguards and ESMF Unit, FONAFIFO and SINAC will define counterparts within each respective institution to attend to the actions established in the ESMF by department.

SINAC:

SINAC is the unit of MINAE created by Article 22 of Biodiversity Law No. 7788 in 1998. It is the governing body in matters of forest management, control of illegal logging, forest fire control, coordination of COVIRENAS and forest inventories. With the exception of measure *3.1.2. Expansion and improvement of financial mechanisms to favor natural regeneration*, which is related to PES and thus falls under the responsibility of FONAFIFO, the remaining six ER Program measures implemented during the reporting period fall under SINAC's jurisdiction. SINAC is organized through a regional system of Conservation Areas that cover the entire national territory and has administrative, human and financial resources at both the regional and local levels staffed by over 1,200 permanent employees. Each Conservation Area has professional, technical and administrative staff to carry out its responsibilities. In addition, the Regional Conservation Area Councils (*Consejo Nacional de Áreas de Conservación*, CORACs) are made up of government and civil society representatives that facilitate the coordination and political direction of work plans at the regional level. In accordance with Biodiversity Law No. 7788, Regional Conservation Area Councils have been established for each of the 11 Conservation Areas a are made up of representatives of society and regional public institutions. Local Conservation Area Committees (*Comités Locales de Áreas de Conservación*, COLACs) have also been created to support and participate in specific processes related to ASPs, forestry, etc.

As a result of this decentralized structure, SINAC had sufficient capacity to ensure the application of the guidelines of the ESMF and comply with the World Bank's environmental and social operational policies both at the central and regional levels during the retroactive period.

SINAC's monitoring capacity is also reflected in its existing platforms that generate and process information that complements the reports within the ESFM. Moreover, SINAC has a long tradition of maintaining administrative records, for which it relies on the powers granted to it by Forestry Law No. 7575, regarding authorizations and permits related to fire control measures, management of protected wildlife areas and control of illegal logging. Platforms include the Forest Resources Information System (*Sistema de Información de Recursos Forestales*, SIREFOR), which was created by Executive Decree No. 33826- MINAE with the "objective of compiling, processing, analyzing, systematizing and periodically publishing official records and updated information on the situation of Costa Rica's forest resources and activities" and the National Ecological Monitoring Program (PRONAMEC) created by Executive Decree No. 39747/MINAE, whose "purpose is to generate and disseminate reliable scientific information on the state of biodiversity conservation in the country and its trends, which is useful for decision-making at the local and national levels, in terrestrial, inland water and marine areas". These programs and systems are under CUSBSE.

FONAFIFO:

FONAFIFO is a government agency attached to MINAE established by Article 46 of Forestry Law No. 7565. It has legal responsibilities and powers in the area of environmental services for the implementation of avoided deforestation projects and ER initiatives and is responsible for developing the PES Program. FONAFIFO keeps an exhaustive record of PES files, as well as documentary evidence of due diligence analysis, consultation processes and selection processes carried out within the REDD+ framework. The roles of FONAFIFO's Directorate of Environmental Services, Department of Control and Monitoring and Department of PES Management in the implementation and monitoring of safeguards is reflected in their respective responsibilities and contributions to the Retroactive Report 2018-2019. The Directorate of Environmental Services is responsible for directing, coordinating, executing and supervising matters related to environmental services. It participated in the support framework of the report by providing the geospatial data for the areas under PES contracts and provided statistics on complementary issues related to the Program's budgets, amounts and modalities. FONFAFIFO has eight regional offices distributed nationwide with a PES Manager (forestry engineer) and assistant. Regional offices supported the placement of PES areas with different modalities and monitored contracts on the farms annually together with the Department of Control and Monitoring.

Budget:

Although there was no specific budget for the implementation of the ESMF during the reporting period, FONAFIFO and SINAC had the financial resources for the development of activities and the implementation and monitoring functions of the ESMF were assumed as part of their general activities at the departmental level.

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.

The professionals of both FONAFIFO and SINAC have attended continuous training events, which provide them with the technical skills to meet their commitments in the framework of the policies to be reported. However, trainings on the topic of safeguards need to be expanded.

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.

Section VIII of the Retroactive Report 2018-2019 details the policies, actions and measures implemented within the ER Program, their scope and approach to risks. As mentioned previously in Section I, environmental and social safeguard plans were not required per the ESMF and national legislation but environmental and social measures were implemented. These are described in detail in Table A1.2, which lists the measures executed in the reporting period with their applicable management instruments and provides highlights of identified risks and mitigation measures taken. According to the ESMF and Retroactive Report 2018-2019, only activities *2.1.3 Strengthening of the Forest Fire Control Program* and *3.1.2 Expansion and improvement of financial mechanisms to favor natural regeneration* entailed risks and impacts since the remaining activities mainly involve capacity building/training actions that did not generate environmental risks or impacts that trigger the requirements of the operational policies. *Activity 2.3.1. Administration and management of ASPs* triggered social risks related to OP 4.10, Indigenous Peoples. This distinction is clarified in the table between activities with Environmental and Social (E&S) risks and activities that did not generate E&S risks and impacts.

Table A1.2 ER Program Management Instruments and Risks and Mitigation Measures

ER Program Measure	**Risks and Mitigation Measures**
Activities with E&S risks	
2.1.3. Strengthening of the Forest Fire Control Program Applicable Management Instruments: • National Fire Management Strategy 2012 - 2021 • Proposed contract for maintenance work on roads, including the need for incident and accident reporting	**Description of Activity:** Activities were focused on improving integrated fire management, including the maintenance and construction of fire mitigation structures, such as firebreaks and roads. It also includes improvements for integrated fire management governance and engagement: the development and implementation of protocols and coordinating procedures among relevant institutions, mechanisms for civil society participation, dedicated regional centers, stronger institutional and legal frameworks, educational programs and a permanent training program. **Identified Risks:** *OP 4.01 Environmental Assessment* - The only identified risk for this measure is the risk of potential accidents/incidents that could arise as a result of the activities carried out in the field. **Mitigation Measures for Identified Risks:** - The construction and maintenance of fire mitigation structures are contracted by SINAC to third parties. Clauses in the terms of references (TORs) clearly establish the safety measures required for the personnel hired by the selected company. These measures include occupational risk insurance policies and social security. **Other Mitigation Measures:** - Fire mitigation structures do not displace areas with forest cover, as there are existing spaces determined for this purpose in the Conservation Areas. - Actions to strengthen the program have relied on the participation of Indigenous Peoples, respecting the guidelines established in the MGCPI, ESMF, FPIC, as well as respect for cosmovision and the organizational and governance structures (both legal and traditional) of Indigenous territories. **Recommendations/Corrective Actions:** - There are no records of accidents reported during maintenance and construction work, but it is recommended that future contracts require the third party in the final TOR to submit a record of accidents/incidence that occur during the corresponding work.
3.1.2. Expansion and improvement of financial mechanisms to favor natural regeneration Applicable Management Instruments: • Executive Decree No. 39871-MINAE, Amendment to the Forestry Law Regulations, Executive Decree No. 25721-MINAE of October 17, 1996. Article 4, Paragraph e. Supports the decisions of the State Forestry Administration, following the principles of Organic Environmental Law No. 7554 and the Forestry Law No. 7575 • Decree No. 39660 – MINAE priorities for the PES • Scope No. 87 to the Gaceta 80 MINAE – FONAFIFO regulation on the Manual for the PES Program • Executive Decree No. 40932 on the General Mechanism of Consultation for Indigenous Peoples • Law No. 7788 Law on Biodiversity • Official DNRAC – UTCI 02-2021 recommendations for the payment for results phase with respect to the General Mechanism for the Consultation of Indigenous Peoples	**Description of Activity:** This measure involves the promotion and management of areas for the conservation and protection of forests and the recognition of environmental services by small and medium producers, Indigenous Peoples and women in a manner that is consistent with the ESMF. The new mixed-PES modality is aimed at small farms with agricultural land use that would otherwise not be able to enter the PES Program. Potential beneficiaries are farm owners with title deeds or title holders titled by INDER with a maximum farm area of up to 10 hectares or a group of farms totaling 10 hectares within a radius of 5 kilometers from each other. The development of new modalities considers existing participation mechanisms that do not infringe on people's rights and the generation of additional sources of work in rural areas and improved access to resources in accordance with traditional uses by surrounding populations, particularly Indigenous territories. **Identified Risks:** *OP 4.01 Environmental Assessment, OP 4.04 Natural Habitats, OP 4.26 Forests* - Land use change resulting in deforestation. - Use of invasive species in the PES program. - Environmental pollution/health and safety issues due to the inappropriate use of agrochemicals.

• Law No. 8839. Law for Integrated Waste Management • Executive Decree 41 931. Regulation of Occupational Health in the Handling and Use of Agrochemicals	- Degradation of natural protected areas. **Mitigation Measures for Identified Risks:** The PES Procedures Manual requires all contracts go through a legal assessment to determine the owner corresponds to the beneficiary requesting entry into the program and a technical study by a qualified professional to determine the environmental obligations depending on the PES modality and activity to avoid associated environmental risks on the environment. This includes an assessment of: - Land use change to make sure areas were not converted from forests. Activity areas must not have undergone land use changes in the last 20 years. - No invasive forest species are used in the PES program. Only native species or the most commonly used exotic species *Tectona grandis* and *Gmelina arborea* are allowed, which are not considered invasive by SINAC and have silvicultural guidelines for their management. - Environmental contamination and health and safety issues due to inappropriate use of agrochemicals. The establishment of agroforestry systems may imply the need to deal with pests. However, these areas do not exceed 10 hectares, use natural species from the area or exotic species with silvicultural studies in the country, which have been established for more than 20 years and are well adapted to natural conditions. The National REDD+ Strategy and PES will not finance an increase in the use of pesticides or other chemicals. Compliance with Law No. 8839 on Integrated Waste Management and Executive Decree 41 931 on occupational health regulations for the handling and use of agrochemicals must be met. There are no records for the period indicating contamination due to inappropriate use of agrochemicals. - In the case of critical natural habitats, no plantations or agroforestry systems are allowed in national parks or biological reserves. Planting of species is only permitted if the ownership of the property is clear and registered and the zoning of the area allows it. **Other Mitigation Measures:** Steps were taken to approach agreements for Indigenous PES and the Procedures Manual for Entry into the PES Program based on studies and consultations carried out within Indigenous territories, resulting in: - Recognition of primary community conservation forests, allowing Indigenous PES to make 2 percent of the area under PES contract for traditional subsistence use in accordance with OP 4.10 Indigenous Peoples and OP 4.36 Forests. - Steps to improve transparency and allow for the application of a scheme that respects the autonomy and cosmovision of Indigenous Peoples. The REDD+ Secretariat respected and promoted steps to ensure the participation of Indigenous peoples, respecting FPIC and the procedures of the GCPI, which builds upon the regulations applicaple to Indigenous Peoples in the MPPI included in the ESMF. It requires (a) defining Indigenous People, (b) prior social studies, (c) regulation of the consultation procedure (dialogues, negotiation and agreements, (d) compliance and monitoring of agreements, (e) definition of impact, (f) respect for representative organizations and (g) culturally appropriate procedures. **Recommendations/Corrective Actions:** The lines of work with Indigenous territories must be established within the framework of the PAFT during implementation.

2.3.1. Administration and management of ASPs <u>Applicable Management Instruments:</u> • Organic Environmental Law No. 7554 • Forestry Law No. 7575 and its regulations • Biodiversity Law No. 7788 and its regulations Executive Decree No. 25721 - MINAE • Wildlife Conservation Law No. 7317 and its amendments: Law No. 9106 Law for the Reform of the Wildlife Conservation Law and its regulations • National Parks Law No. 6084 • Executive Decree No. 39519-MINAE, recognition of governance models in ASPs of Costa Rica • Executive Decree No. 40932-MP-MJP National Mechanism for the Consultation of Indigenous Peoples	**Description of Activity:** The activities aim to improve processes and guarantee adequate implementation of ASPs in Costa Rica. The ESMF did not identify negative environmental impacts, as the measure is mainly focused on activities that strengthen ASPs through the development of management plans to promote activities to mitigate and adapt to climate change. This includes administrative activities and processes to guarantee the provision of ecosystem services to society in general. **Identified Risks:** *OP 4.10 Indigenous Peoples* The measure activated OP 4.10 Indigenous Peoples and the procedures identified in the ESMF due to the participation of Indigenous Peoples in the safeguarding of natural resources and management of sacred areas. **Mitigation Measures for Identified Risks:** Includes attention to ASPs and the Indigenous Chapter of the National Forestry Development Plan and the MGCPI to consult Indigenous Peoples through appropriate procedures and through their representative institutions. Mechanisms have been developed to follow up, evaluate and analyze the social, economic and environmental environment in which the national policy is implemented. **Recommendations/Corrective Actions:** It is important to visualize Indigenous communities in the management of ASPs to avoid invalidating management processes within ASPs and conflict with Indigenous communities. The lines of work with Indigenous territories must be established within the framework of the PAFT during implementation.
Activities that did not generate E&S risks or impacts	
2.1.1 Promote the generation and implementation of forest fire prevention campaigns <u>Applicable Management Instrument:</u> • National Fire Management Strategy 2012 - 2021	This measure promotes the reduction in deforestation and degradation in ASPs through the planning, generation and implementation of forest fire prevention campaigns across the country. The ESMF did not identify any negative environmental impacts. Communication processes were carried out at the national level but did not generate actions in the field that could impose a risk to the environment. OP 4.10 Indigenous Peoples was not triggered, but the governing body for the consultation mechanism, the MJP recognized that the REDD+ Secretariat respected and promoted steps to ensure the participation of Indigenous Peoples, respecting the MPPI in the ESMF. The fire prevention campaigns were linked to the topic of forests and cosmovision as a result of the consultation processes. The need to work on this topic was identified in the Indigenous Peoples Chapter of the National Forestry Development Plan and was therefore a prioritized activity. SINAC's regional offices with Indigenous territories coordinated actions to address the implementation of preventative activities with territories surrounding the ASPs. The needs identified by the territories during the Strategy's consultation process will help prepare the PAFT.
2.1.2 Monitoring and promotion of volunteer forest fire departments <u>Applicable Management Instruments:</u> • National Fire Management Strategy 2012 - 2021 • National Guide for the Training and Certification of Personnel in Integrated Fire Management • Procedures and Guidelines for Handling Warehouses, Vehicles, Tools, and Others	The measure promotes positive effects on forests and other ecosystems by promoting and training institutional and volunteer forest fire departments that respond to incidents within and outside of ASPs. Activities were focused on improving and providing positive benefits for fire management, such as training, raising awareness and strategy development. The ESMF did not identify any negative impacts, however it was considered that incidents may occur during training. Communication with the Program Director confirmed that there were no incidents/accidents during the reporting period. This information will be collected in future reporting and steps will be taken to focus future efforts on evaluating existing danger to resolve or reduce accidents. The ESMF requires volunteer fire departments comply with institutional guidelines and procedures established for fire control and accident prevention. Includes conditions that the contracted company must meet, i.e. qualifications and age requirements for positions (brigade leaders, supervisors, firefighters). The "backpack test" was applied to assess the physical condition of firefighters and their ability to work in adverse

	conditions while carrying personal protective equipment. Volunteer firefighters and SINAC officials must have a health policy covering up to 50 million colones in case of death or disability and 10 million colones for medical expenses due to accidents. Indigenous Peoples have sacred sites or natural cultural resources within ASPs, making it critical to consider their participation and dialogue in addressing fires near ASPs. More engagement and language-appropriate information and training needs to be directed to Indigenous territories in the North and South Pacific where fire incidence is high to increase the participation of Indigenous men and women in volunteer fire brigades. Indigenous territories have resource guards (*guardarecursos*) made up of men and women that have had a demonstrated effect in protecting natural resources and may be trained to form these brigades. Lines of work with Indigenous territories must be established within the framework of the PAFT during implementation.
2.2.1. Strengthening of the Illegal Logging Control Program Applicable Management Instruments: • llegal Logging Control Strategy • Forestry Regulations of the College of Agronomist Engineers • Procedure for the Supervision of Stationary Industries • Principles and Criteria and SFM (Sustainable Forest Management) Code of Practice for Primary Forests • Principles and Criteria and SFM Code of Practice for Secondary Forests • Action procedures for the Control of Portable Industries • Procedure for the Confiscation of Timber, Goods and Equipment used in the Commission of Illegal Activities established in Forestry Law No. 7575 and its Regulations • Procedure for the Donation, Return and Destruction of Confiscated Goods or other Goods in SINAC's possession • Methodological Guide for Preparing Prevention, Protection and Control Plans in Protected Areas and SINAC Subregional Offices • Interviews with the Climate Change Coordinator and the Coordinator of the Incentives Program, CUSBSE • Electronic communications with the Head of SINAC's PPC Department	The strengthening of land use change prevention and control programs combat the dynamics of deforestation-degradation and take actions to overcome the gaps detected in forest governance that promote illegal logging. The measure seeks to strengthen illegal logging control and monitoring processes by simplifying procedures that make the activity more expensive and by promoting efficient institutional systems. The ESMF did not identify any negative environmental impacts in this measure. Actions were aimed at preventing deterioration and promoting the conservation and protection of forests through compliance with legal and technical regulations on use and harvesting, control of stockpiling and transportation and detection of illegal forestry practices. These actions were carried out within the framework of the national regulations in force, which comply with the World Bank's operational policies. Indigenous territories play a buffering role for ASPs and the protection of their natural resources. Indigenous dialogue is necessary to define the use of natural resources in ASPs and Indigenous territories to establish clear guideliness for use and access. Guardarecursos have been promoted in several Indigenous territories and have allowed for early action related to the protection of natural resources. The lines of work with Indigenous territories must be established within the framework of the PAFT during implementation.
2.2.2. Reactivation of COVIRENAS Applicable Management Instruments: • Executive Decree No. 39833-MINAE, Regulation of COVIRENAS • Executive Decree No. 40357-MINAE officializes the forms for the registration of the COVIRENAS and ad honorem environmental inspector, in addition to Executive Decree No. 39833 - MINAE	The promotion of citizen education and participation to reactivate COVIRENAS has enabled the voluntary participation of individuals and/or civil society organizations to contribute to the conservation of natural resources. Engagement has extended to young people and especially Indigenous Peoples, since the latter play a buffering role for protected areas. Due to the nature of these training activities, the ESMF did not identify any negative environmental impacts of this measure. The formation of COVIRENAS does not trigger OP 4.10 Indigenous Peoples. Spaces had been established for their voluntary and free participation, under the requirements established by the decree for the formation of COVIRENAS. The first committees were established and there are currently four COVIRENAS in Indigenous territories. The lines of work with Indigenous territories must be established within the framework of the PAFT during implementation.

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).

Section VIII of the Retroactive Report 2018-2019 details the entities in charge policies, actions and measures implemented within the ER Program and the monitoring instruments. Based on the report, Table A1.3 lists the entities responsible for keeping consistent and comprehensive records of ER Program activities and the corresponding monitoring instruments used in the reporting period.

Table A1.3 ER Program Institutions/Responsible Departments and Monitoring Instruments

ER Program Measure	Institution/Responsible Dept.	Monitoring Instruments
2.1.1 Promote the generation and implementation of forest fire prevention campaigns	SINAC, PPC, National Fire Management Program	• Annual report of actions carried out by the Integrated Fire Management Program (SINAC PPC) - Reports of forest fire prevention campaigns 2018 -2019 - Systematization of dissemination and communication activities carried out by the conservation areas • Interviews with the Coordinator of the National Fire Management Program SINAC-MINAE • Appendices included in the Retroactive Report 2018-2019 of the different activities carried out in the 2018-2019 campaigns
2.1.2. Monitoring and promotion of volunteer forest fire departments	SINAC, PPC, National Fire Management Program	• Annual report of the Integral Fire Management Program (SINAC PPC) on the dissemination and communication activities carried out by conservation areas • Contracts for the hiring of fire departments and forest firefighters • Interviews with the Coordinator of the National Fire Management Program SINAC-MINAE
2.1.3. Strengthening of the Forest Fire Control Program	SINAC, PPC, National Fire Management Program	• Annual report of the Integral Fire Management Program (SINAC PPC) on the dissemination and communication activities carried out by conservation areas • Contingency plans • Early Warning System for Forest Firest (*Sistema de Alerta Temprana en Incendios Forestales*, SATIF) application for phones • Consultancy report for the development of the Indigenous Chapter for the updating of the National Forestry Development Plan • Interviews with the Coordinator of the National Fire Management Program SINAC-MINAE
2.2.1. Strengthening of the Illegal Logging Control Program	SINAC, PPC, Department of Development Management, CUSBSE	• Annual work report of prevention, protection and control by CUSBSE • Information from SIREFOR • Annual statistics report of the Continuous Quality Evaluation System (Sistema de Evaluación del Mejoramiento Continuo de la Calidad, SEMEC 2018) • Annual report on the implementation of the Illegal Logging Control Strategy of the SINAC PPC • SINAC granted a series of land permits processed through online information systems, the Management Plans System (*Sistema de Planes de Manejo*, SIPLAMA) for forest management plans and the Information System for Forest Harvesting Control (*Sistema de Información para el Control del Aprovechamiento Forestal*, SICAF) for non-forest agricultural land
2.2.2. Reactivation of COVIRENAS	SINAC, PPC	• SEMEC 2018 • Interviews with the Climate Change Coordinator and with the Coordinator of the Incentives Program, CUSBSE • Electronic communications with Head of the SINAC PPC. • Executive Decree N° 39833-MINAE Regulation of COVIRENAS • Executive Decree N° 40357-MINAE officializes the forms for the registration of the COVIRENAS and ad honorem environmental inspector, in addition to Executive Decree No. 39833 - MINAE
2.3.1. Administration and management of ASPs	SINAC, CUSBSE, PCG	• Interviews and electronic communications with: ASP Program Coordinator, Jenny Ash, Forever Costa Rica National Program Coordinator, Mauricio Arias and CUBSBE • Protocols, guidelines and guides for the development of actions within the ASPs • Reports of actions of the Conservation Areas with their ASPs under administration

		• Land Tenure Management System in State Natural Heritage Lands and ASPs, a web platform for SINAC officials which manages certifications, visas, purchases, donations and inscriptions of vacant land, with their respective review processes
3.1.2. Expansion and improvement of financial mechanisms to favor natural regeneration	FONAFIFO, Directorate of Environmental Services	• Annual Reports on the execution of the PES Program • Interviews and electronic communications with the Director of Environmental Services Directorate • Procedures Manual for the Operation of the PES Program • Farm files with the respective contracts and supporting documentation • Minutes of FONAFIFO's Board of Directors, with agreements made in the 2018-2019 retroactive period • Consolidated reports of the PES Promotion and Monitoring Strategy

Records of handling complaints and feedback under MIRI are summarized in Section 2.2.4 of this annex and detailed in Section X of the Retroactive Report 2019-2019.

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.

While Table A1.2 above provides an outline of the environmental and social management measures taken during implementation, below are additional details describing the extent to which these measures have been implemented in practice to mitigate risks. This section of the annex focuses specifically on measures and actions that triggered E&S risks, but Section VIII of the Retroactive Report 2018-2019 describes all the policies, actions and measures implemented within the ER Program during the reporting period and the risks and impacts that were addressed.

2.1.3. Strengthening of the Forest Fire Control Program

In the retroactive period, SINAC made investments to ensure the mitigation actions established in the ESMF as part of the activities in the National Fire Management Program, i.e. maintaining firebreak patrols in areas identified as high incidence and equipping institutional and volunteer forest firefighters and hiring reinforcement brigades. Table A1.4 details the extent of the fire mitigation infrastructure constructed in the retroactive period:

Table A1.4 Fire mitigation infrastructure constructed in Conservation Areas in the retroactive period

Conservation Area	Maintain Roads (2018)	Construct/Maintain Firebreaks (2018)	Maintain Roads (2019)	Construct/Maintain Firebreaks (2019)	Total in Retroactive Period
	Length (km)	Length (km)	Length (km)	Length (km)	
Arenal Tempisque	50	199.5	50	195.5	495
Tempisque	8	43.44	38	89.44	178.88
La Amistad Pacífico	-	94	0	101.5	195.5
Guanacaste	177	168.38	252	188.28	785.66
Pacífico Central	-	12	0	13	25
Central	-	1.1	-	-	1.1
TOTAL:	235	518.42	340	587.72	1681.14

Road maintenance and firebreak construction work was contracted by SINAC to third parties. To address the potential incidents that could occur as a result of the activities that were carried out in the field to maintain and build fire mitigation infrastructure, the third parties were required as part of their contract to have social security and accident risk policies in force. There are no records of accidents reported during the retroactive period, but it is recommended that future contracts record incidence during the implementation of the Emissions Reduction Program.

SINAC has provided the necessary resources to safeguard the health of the staff and equipment contracted in the response to forest fires. Personal protective equipment acquired during the retroactive period consisted of: helmets, smoke goggles, long-sleeved shirts, short-sleeved shirts, leather gloves, pants, high boots, back canteens, helmet flashlights, face protection, smoke masks, belts, backpacks and radio holders. In addition, tools and equipment were acquired for the effective use of water, vehicles, heavy machinery, firefighting vehicles, radio communication and technology.

Consultations with Indigenous representatives have highlighted the importance of strengthening Indigenous engagement for the prevention, use and management of forest fires. However, fire continues to be an issue impacting Indigenous communities in the North and South Pacific. SINAC and PPC need to expand collaboration with Indigenous territories, especially where the incidence of fires is high. The National Forest Fire Program needs to establish clear protocols and establish strategic points to control forest fires effectively in susceptible Indigenous territories.

3.1.2. Expansion and improvement of financial mechanisms to favor natural regeneration

Based on feedback from Indigneous Peoples in the consultation processes executed by FONAFIFO, improvements were incorporated into the PES during the reporting period to respect their automony and worldview. These improvements were included via executive decree in such a way that their application was immediate and provided more transparency for the execution of resources by the Integrated Development Association (*Asociación de Desarrollo Integral*, ADI) as well as technical improvements in the implementation of the forest protection modality. The proactive work of FONAFIFO's Board of Directors and the administration eliminated administrative obstacles and requirements for modalities with small producers, making it possible to expand coverage to traditionally excluded populations. Significant achievements have been made in expanding and improving incentives for forest conservation and management. In addition, the continuity of these changes are supported by management procedures explicitly stated in the PES Procedures Manual. PES for Indigenous territories has continued to gain momentum. ADI located in Indigenous territories had secured 112 contracts in 2018 and 118 in 2019. Additionally, despite the tenure condition that exists at the national level, in which only 15 percent of women have farms titled in their name, in 2018 there were 666 women with contracts formalized within the PES (13 percent of all PES contracts) and in 2019 (14 percent of all PES contracts).

The management of environmental risks has also been detailed in the PES Program Procedures Manual, which is currently being implemented. This includes the requirement that a technical study must be prepared by a qualified professional and reviewed by FONAFIFO to determine whether all necessary aspects have been evaluated and considered. Table A1.5 lists the obligations established in the Operations Manual for the environmental issues that must be addressed for each PES modality. Additional considerations to mitigate environmental risks that have been implemented are described in Table A1.2 earlier in the annex.

Table A1.5 Obligations established in the Operations Manual for each PES Modality

PES Modality	PES Activity	Obligations Established in the Operations Manual
Maintain Forest Cover	Protection Water Resource Protection Post-Harvest Protection	Program activities, especially forest protection, are strengthened by the incorporation of criteria in the PES Program's farm evaluation matrix, which allows for the identification of conservation needs at the national level and specific protection measures, such as forests located on farms identified by technical studies as conservation gaps and farms located within biological corridors. Article 21: Protection obligations 21.1. Not to carry out logging, extraction or harvesting activities that alter, damage or undermine the natural behavior of the forest.

		21.2. Carry out actions to protect against damage caused by third parties. As a minimum: demarcation of the forest area, existence of lanes or fences, supervision and periodic monitoring of the area at least every three months. 21.3. In the event of logging and/or alterations to the forest by third parties, hunting activities or any other activity that may damage the forest, the beneficiary must file a criminal complaint with the Public Prosecutor's Office and an administrative complaint with SINAC within 15 calendar days of learning the fact. Copies of these complaints must be sent to the regional office of FONAFIFO no later than 30 calendar days after they are filed, along with the forestry regency report quantifying the damages and impacts produced.
Recover Forest Cover	Natural Regeneration	Article 5. Prioritization criteria 5.4 Priority will be given to denuded areas, areas without forest cover, areas with nearby seed sources, areas in recovery and farms without grazing. Article 24. Obligations 24.1. Protect the vegetation cover in areas where regeneration processes occur, not to cut trees or any other type of vegetation and protect from damage by cattle or any other animal. 24.2. Do not carry out any activity that alters the natural behavior of the area to be protected. 24.3. Make a description of the resource (saplings and commercial grasslands), presence of remnant trees, nearby seed sources, or other ecological aspects relevant to secondary succession, denuded areas, areas without forest cover, but which are in the process of regeneration and which do not meet the definition of forest and free of grazing. 24.4. Carry out necessary actions to protect the regenerating area from damage by third parties and animal grazing, such as: demarcation of the area, existence and cleaning of lanes, fire breaks in fire-prone areas, supervision and monitoring of the project area every three months.
	Reforestation	Article 5. Prioritization criteria 5.3 Areas without forest with productive potential. As well as Executive Decree 25663-MINAE regulates the cutting or harvesting of almond trees. Executive Decree 25700-MINAE declares a total ban on the harvesting of endangered trees. Article 22. Obligations 22.2. Maintain the forest plantation during the term of the contract, executing all maintenance and silvicultural management actions techniques according to the science. 22.4. Perform actions necessary to protect the plantation from damage by third parties, such as: demarcation of the area, existence and cleaning of lanes, fire breaks in fire-prone areas, supervision and surveillance of the project area every three months. 22.5. Do not carry out agricultural activities that are incompatible in the plantation area; if the farm has an area dedicated to these purposes, it must be fenced or delimited so that these actions do not harm the processes occurring in the plantation. This incompatibility of agricultural activities must be included in the technical study and approved by FONAFIFO. 22.6. If unauthorized logging or alterations to the forest are made by third parties, alterations to the plantation made by third parties, hunting activities or any other activity that may damage the forest, the beneficiary must present a criminal complaint to the Public Prosecutor's Office and an administrative complaint to SINAC within 15 calendar days of learning of the facts. Copies of these complaints must be sent to FONAFIFO's regional office no later than 30 calendar days after they are filed, along with the forestry regency report quantifying the damages and impacts produced. 22.9 In short rotation, fast or medium growth reforestation projects, only projects that use reproductive material with genetic improvement, with tolerance to pests and diseases and with availability of seeds or clones certified by the National Seed Office shall be accepted.

		The regent must certify the improved vegetative material when it exists or, in its absence, the origin of the material selected for planting. 22.10 Document the incidence of attacks by pests or diseases (estimate of the degree of affectation and the amount of area or quantity of trees affected), sending FONAFIFO information on the state of the plantation during the term of the contract. Annex Manual Guidelines for preparing the reforestation technical study and SAF 1.6. Must show the interpretation of the soil analysis and indicate, when applicable, the recommendations for soil preparation, acidity correction, fertilization and other actions required according to the results of the analysis. 2.7. Make an evaluation of the physical-environmental, ecological and silvicultural factors, with which it shall recommend the species, sites to be planted and the management of the species. 3.8. Include the common and scientific name(s) of the species to be used in the plantation(s) and clearly indicate each species in each area, for each real folio; as well as the planting density of each species, duly justified; with priority to species with genetic improvement certified by ONS. 4.9. In all cases, detail the recommendations for the correct preparation of the land before and during planting, together with a program of maintenance and silvicultural management activities during the life of the project.
	Agroforestry Systems (SAF)	23.2. Protect trees from browsing by animals in silvopastoral systems and other types of SAF. 23.3. Carry out the necessary actions to protect the SAF from damage by third parties; these protection actions shall include, at a minimum: demarcation of the planting area, existence and cleaning of lanes or fences, fire breaks in fire-prone areas and periodic supervision and monitoring of the project area at least every three months. 23.5. Only projects that use genetically improved reproductive material, with tolerance to pests and diseases and with the availability of certified seeds or clones, whose origin is certified by ONS, will be accepted in PES projects. The Forest regent must certify the origin of the improved vegetative material when it exists or, in its absence, the origin of the material selected for planting. 23.8. Existing trees of timber species or multiple use species, regardless of their age, will be accepted in the mixed system-SAF. 23.9. Document the incidence of attacks by pests or diseases (estimation of the degree of affectation and the amount of area or quantity of trees affected), sending FONAFIFO information on the state of the system during the term of the contract. Annex Manual Guidelines for preparing the reforestation and PES technical study 5.6. Shall show the interpretation of the soil analysis and indicate, when applicable, the recommendations for soil preparation, acidity correction, fertilization and other actions required according to the results of the analysis. 6.7. Make an evaluation of the physical-environmental, ecological and silvicultural factors, with which it shall recommend the species, sites to be planted and management. 7.8. Include the common and scientific name(s) of the species to be used in the plantation(s) and clearly indicate each species in each area, for each real folio; as well as the planting density of each species, duly justified; with priority to species with genetic improvement certified by ONS. 9. In all cases, it must detail the recommendations for the correct preparation of the land before and during planting, together with a program of maintenance and silvicultural management activities during the life of the project.

There is a PES Promotion and Monitoring Strategy for the period 2013-2018, which reports actions carried out between SINAC and FONAFIFO for the implementation of the Program. The regional offices and PES monitoring staff carry out annual monitoring of PES contracts (generally a sample of 10 or 15 percent of contracts). In 2018, a total of 273 monitoring visits were made to areas subject to PES approved by FONAFIFO, with an area of 16,096.93 ha, with the majority of visits to the forest modality (75 percent). Likewise, SINAC registered 310 projects with an area of 24,248.48 ha for forestry incentives. For 2019, more than 95 activities were carried out, such as talks, workshops, training, field tours, experience exchanges and technical presentations in which the different Conservation Areas participated in support of the PES Program, as established in the Strategy. A total of 341 follow-up visits were made to areas subject to PES approved by FONAFIFO.

2.3.1. Administration and management of ASPs

Working from the beginning with the Indigenous communities fostered important alliances between the parties and to recognize the traditional uses of the ecosystems through a process of prior, free and informed consultation and recognition of the non-traditional uses in the different ASPs. Based on the different management instruments applied, it has been possible to identify social and economic linkages that will generate benefits for local communities, including Indigenous communities, that are culturally appropriate and inclusive from an intergenerational and gender point of view.

In terms of monitoring and evaluation, the activity has prompted the development of the necessary mechanisms to follow up, evaluate and analyze the social, economic and environmental impacts of the national ASP, as well as internal coordination and communication processes that adequately report on compliance with the policies. A Tool for the Evaluation of Management Effectiveness of ASPs was developed to monitor and evaluate ASP management and improve administrative processes through the systematization of information for better decision making. The tool facilitated an adaptive management approach, helped allocate resources efficiently, promoted transparent accountability to different stakeholders and facilitated the involvement of strategic allies to promote ASPs. It structured the monitoring and evaluation of the social dimentions of ASPs, including patterns and intensity of resource use, volunteer plans, communications, environmental education, sustainable tourism and participation. As a result of the application of the tool, reports on the management of PSAs and improvement plans were developed.

In 2018, the Strategy and Action Plan for the Participatory Strengthening of the World Heritage Site La Amistad Caribe (*Estrategia y Plan de Acción para el Fortalecimiento participativo del Sitio Patrimonio Mundial de la Humanidad-Área de Conservación la Amistad Caribe*, SPMH-ACLAC) was developed with the objective to carry out a diagnosis based on the relationship between the populations linked to the SPMH-LAC, particularly seven of the eight Indigenous territories (two Bribri and five Cabécar) of the Caribbean coast and ACLAC, taking into account the dynamics of the territories themselves, their models of coexistence, care and use of nature and their conservation culture, in order to consolidate a satisfactory governance structure. The participatory process resulted in greater awareness of the Indigenous population about natural resource threats in their territoires.

The activity has supported the development of internal coordination and communication processes to adequately report on compliance and improve governance regionally and nationally. The implementation of different guidelines and robust operating procedures for ASPs requires constant work and more human resources dedicated to their management are needed. As a mitigation measure to address missing plans in ASPs, a work improvement plan has been proposed for SINAC to allow the exchange of officials from Conservation Areas with experience in developing specific plans for the management of ASPs to help fill in the missing plans in the remaining ASPs.

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.

Section X of the Retroactive Report 2018-2019 provides a detailed description and analysis of MIRI based on the reports of the FONAFIFO and SINAC comptrollers. The MIRI was validated by relevant stakeholders and functional, allowing stakeholders to clarify their requests for information, express their disagreements and to provide feedback on the implementation of the REDD+ Strategy.

To strengthen communication, MIRI has applied a legal framework to regulate, organize and operate the system of Service Comptrollers as a mechanism to guarantee the rights of users of public services (Regulatory Law of the National Systems of Comptroller Services No. 9158). Given the Executive Decree No. 4064-MINAE creates the REDD+ Executive Secretariat integrated by SINAC and FONAFIFO, these two institutions have proposed their service comptrollers to meet the needs of MIRI. Based on its broad experience and capacities, FONAFIFO's Comptroller of Services assumes responsibility for the overall management of the mechanism, accounting and reporting. A wide range of communication are made available to ensure inclusiveness, including through the SITADA if the MINAE Environmental Comptroller redirects an applicable complaint, e.g. those that correspond to Conservation Areas to SINAC. Table A1.6 details MIRI requests in the reporting period by communication channel.

Table A1.6 MIRI requests received by communication channel during the reporting period (2018-2019)

Channel	Website	Email	Online Chat	Phone	Participation Fairs	On-Site	SITADA	Suggestion Box
2018	140	82	23	23	9	3	0	1
2019	25	134	0	17	0	1	6	0

There has been a continuous reduction in the number of MIRI requests: 2018 recorded 100 fewer requests than 2017 and 2019 had a reduction of 96 compared to 2018. This was partially due to improvements to the institutional website that reduced the number of queries, providing a more interactive design, an organized structure and updated relevant information. Table A1.7 breaks down the types of requests received.

Table A1.7 Types of requests received by MIRI during the reporting period (2018-2019)

Type of Request	2018	2019
Query	253	162
Non-conformities	22	14
Complaint	2	7
Suggestion	1	0
Congratulation	1	0

Most of the inquiries received by MIRI have been general PES inquiries related to requirements, such as general program information, entry dates, how to get an appointment, payment statuses and payment amounts. Non-conformities in 2018 concerned administrative issues, but in 2019 were related to excessive paperwork in the PES, problems with the computer system for contract consultations and delays in payments. Complaints received during the 2018-2019 period referred to alleged illegal activities (burning and logging) occurring in areas subject to PES. These complaints were addressed by the managers of the regional offices of Nicoya, Limón and San José Occidental, determining through inspections coordinated with the trustees (*regentes*) that the areas in question were not within the PES scheme and, therefore not in FONAFIFO's power to proceed with legal actions in the face of non-compliance. As a next step, FONAFIFO's Comptroller of Services returned these consultations to SITADA for follow-up. Both institutions, SINAC and FONAFIFO, keep in their records the respective follow-up of the complaints filed in SITADA, as well as the respective paperwork carried out.

On average, issues were responded to in three days—considerably below the 15-day timeframe established by law. The Comptroller's Office is therefore a consolidated mechanism that is gradually gaining relevance among users due to its proven effectiveness in handling procedures and which is strictly monitored both by the authorities of the institution and by external audit bodies (MIDEPLAN) to verify compliance with deadlines, safeguarding of regulations and the achievement of its objective as a facilitator and promoter of continuous institutional improvement.

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.

The management and mitigation ESMF measures implemented have been effective during the reporting period, as evidenced by the details provided in Section 2.2.3 and Section 2.2.4.

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?

The efficacy of these arrangements is evidenced by the details provided in Section 2.2.3 and Section 2.2.4. The objectives and the expected outcomes have been achieved. No cases have been identified of ER Program activities not implemented in accordance with the ESMF.

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)?

Section 2.1.1 summarizes the supervision and oversight arrangements in place for the ER Program while Section 2.2.2 details the institution and department in charge of monitoring each measure. The efficacy of these arrangements is evidenced by the details provided in Section 2.2.3 and Section 2.2.4.

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?

The SESA provided a comprehensive list of environmental and social risks and corresponding mitigation measures. The Strategy's measures were created as a result of the processing and synthesis of this information. The scope of the identified risks and potential impacts has been maintained and continue to be relevant to ER Program activities. Measures and actions carried out in the 2018-2019 reporting period have been executed in accordance with the procedures, guidelines and operational norms of the related institutions, which has allowed the continuous compliance with the ESMF and due attention to the operational policies.

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?

No ER Program activities have led to risks or impacts that were not previously identified in the Safeguard Plans prepared prior to ERPA signature. Environment and social management measures have not required updating. However, as more activities are implemented with the economic resources from the results-based payments, environmental and social risks may emerge that have not been identified or anticipated prior to the ERPA signature and may result in improvements or updates to the ESMF.

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

Section IX of the Retroactive Report 2018-2019 provides a general overview of the implementation of the Safeguards Plans, corrective actions and improvements needed to enhance effectiveness. Overall, the policies, actions and measures defined in the ER Program and specifically those mentioned in the Retroactive Report 2018-2019 have promoted the generation of multiple positive impacts in social and environmental areas of the National REDD+ Strategy. Through the actions carried out in the reporting period for the different measures, it was possible to address the identified drivers of deforestation and forest degradation while also implementing risk guidelines and the mitigation measures envisaged for the activities in the ESMF.

It is important to highlight that institutional efforts were carried out hand in hand with the collaboration of Costa Rican citizens to mitigate risks, through their inclusion as recipients of information (through campaigns, educational events and information on fires), active participants in prevention (through specialized events for producers and field operations) and inclusion in implementation measures (through participation in volunteer fire brigades or COVIRENAS). Although there is a whole regulatory framework for working with Indigenous territories and forest owners at the national level, additional steps to improve their participation and inclusion are needed.

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

While there were no negative or unanticipated impacts evidenced in the field, recommendations and improvements have been proposed to enhance the effectiveness of safeguard measures. The following lists the recommendations and opportunities for improvement, which will be reported in the next period's safeguards report, as well as the expected timelines where available:

Reporting Accidents

- Include a clause in the final TOR for works that are carried out through external contracting processes within the Fire Management Program, requiring the contracted third party to submit a record of accidents/incidents that occur during the corresponding work. *Begin recording in 2022.*

Institutional Strengthening for the Implementation and Follow-Up of the ESMF

- Improve the precision of monitoring through a Steering Committee agreement establishing the type of information required for safeguards reports, deadlines, mechanism for submission and person in charge. *This agreement with these guidelines will be implemented in 2022.*
- Establish the REDD+ Secretariat ESMF and Safeguards Unit to support the collection, analysis, processing and follow-up of safeguards information and engagement with stakeholders and sectors in the field. *This team will be integrated and formed by March 2022, provided that the results-based payments resources are available.*
- Continue capacity building in operational policy issues and the World Bank's safeguards for all personnel involved in the implementation of actions in the field. *These capacity building measures will be implemented starting March 2022.*

Improving Stakeholder Engagement

- Although Spanish is spoken in most of the territories, priority should at least be given to the languages of the peoples or territories where the incidence of forest fires is higher, in order to promote more inclusive information and attention to fire risks.
- SINAC's Fire Management Program should include more planning and joint work with Indigenous territories, specifically where the incidence of fires is high and community structures for natural resource management should be promoted or strengthened.
- Additional work is required by FONAFIFO and SINAC to include the entire population, including Indigenous territories. Although there is a whole regulatory framework for working with these territories, there are still measures that have not been fully inclusive in the development of verbal and written information such as campaigns, creation of fire departments and forest firefighters in their native languages.

- Activities related to Indigenous populations must continue in accordance with the procedures in the MGCPI to construct the PAFT in compliance with agreements and safeguards with consideration to existing internal structures recognized by the community and inputs from the National REDD+ Strategy consultations.

Improving MIRI

- Centralize all the information in one system with the details and characteristics needed to make a single report, without differentiating the origin of the information institutionally.
- Allow comptrollers' offices to filter MIRI activities by subcategories to better distinguish between minor and major issues, such as complaints about access to the web page versus more important concerns (e.g. complaints from some relevant interested parties about lack of participation).

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

See Section 5.2 above.

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

This annex is a brief overview based on the Advanced Draft of the BSP and inputs from the Government of Costa Rica after a World Bank mission in July 2021. Given the annex refers to the period between January 2018-December 2019, some sections of the template do not apply entirely to this retroactive period because the ER Program was in its nascent stages and the BSP had not been implemented. Nevertheless, the sections have been completed to the extent possible.

I. Requirements of FCPF on Benefit Sharing Plans

During the retroactive period between January 1, 2018 and December 31, 2019, the BSP was in a draft stage and not yet implemented. An advanced draft of Costa Rica´s BSP was accepted by the FCPF FMT on June 18, 2020, and the FCPF Carbon Fund Participants provided their no objection on July 3, 2020. The COVID-19 pandemic, beginning in March 2020, interrupted the finalization of the BSP and prevented stakeholder consultations on the Advanced Draft, primarily with Indigenous Peoples. The preparation of a final version of the BSP is a Condition of Effectiveness of the ERPA and will be prepared by November 2021.

The BSP was designed by Costa Rica's REDD+ Secretariat, based on a broad legal framework to propose the distribution of benefits from the implementation of the REDD+ Strategy and more specifically the ER Program. The BSP complies with the main elements and requirements established by the criteria and indicators in the FCPF Methodological Framework regarding "Benefit Sharing" (No. 5.2)–which requires ER Programs to use clear, effective and transparent benefit sharing mechanisms with broad community support and backing from other relevant stakeholders, as well as to ensure that benefit sharing is carried out with respect to the importance of guaranteeing legitimacy in the decision-making process; respecting customary rights over lands and territories; and complying with the objectives of effectiveness, efficiency and equality. The BSP embodies the principles of legality, effectiveness, efficiency, equality, transparency, citizen participation and inter-cultural sensitivity.

The objective of the BSP is to guide the distribution of benefits derived from the commercialization and sale of greenhouse gas emission reductions generated by the country, which have been duly incorporated into the reduction registry established for such purposes, and over which there is an agreement for the transfer of rights or a marketing authorization by its owners (whether public or private), specifically the resources stemming from the implementation of the ER Program signed with the Carbon Fund. Article 15 of REDD+ Decree No. 40464-MINAE states that resources from the commercialization of ERs shall be distributed according to the percentage of contribution of each of public or private entity that own ERs. The decree was shared with the relevant stakeholders and feedback was duly addressed. The initial allocation of ER payments is based on the share of the total forest land area, which are then invested in or channeled through four benefit sharing mechanisms: i) SINAC Strengthening Plan, ii) CREF, iii) Green Business Fund and iv) Inclusive Sustainable Development Fund.

Monetary benefits will be properly distributed among the different stakeholders involved in the execution of REDD+ actions at the local level and there are national mechanisms created under the REDD+ framework to demonstrate transparency in the distribution of monetary benefits—with mechanisms for monitoring, accountability and means to enable access to information. All environmental and social management guidelines and procedures established in the ESMF of the ER Program are applicable in the implementation of the BSP. The risks or potentially adverse environmental and social impacts (and corresponding mitigation measures) of the implementation of the ER Program activities and this BSP have been duly analyzed and communicated to stakeholders during the development of the ESMF.

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?

The process of disseminating and collecting feedback on the BSP began with the "Workshop to Identify Elements for the Basis of the REDD+ Benefit Sharing Plan" in April 2016.[100] It is important to highlight the ample participation of women in the BSP workshop (65 percent of participants), as well as in the process of developing the National REDD+ Strategy, SESA and ESMF. After consulting the relevant stakeholders from non-governmental organizations (Fundecor and UCIFOR), Indigenous Peoples (Red Indígena Bri Bri-Cabecar, RIBCA) and government institutions (Directorate of Climate Change, DCC), the Government of Costa Rica published Executive Decree 40464-MINAE in July 2017. Article 15 of the Executive Decree provides the general guidelines for the REDD+ Benefit Sharing System. Based on these guidelines, in 2018 the REDD+ Secretariat prepared the first version of the BSP, which was shared with relevant stakeholders via email on two occasions.[101] The REDD+ Secretariat also posted the BSP document on its website for a month to ascertain the positions of relevant stakeholders.

During the reporting period, the following information and consultation activities directly related to the BSP were held with different stakeholder groups of ER owners. Participants included representatives appointed by the institutions, community leaders and representatives of the Boards of Directors of Indigenous Peoples.

Table A2.1 BSP Consultation Activities

Date	Activity	Stakeholder Group	Details
July 15, 2019	Workshop with Leaders and ADIs of Indigenous Territories	24 Indigenous Territories REDD+ Secretariat Number of Individuals: 66 (18 women, 48 men)	Consultation and dissemination of the proposed BSP draft to be sent to the World Bank. In this workshop, it was agreed that the REDD+ Secretariat will contact the ADIs of the territories to submit the Advanced Draft of the BSP, and that each territory will decide whether to participate in said Plan.[102]
July 22, 2019	REDD+ Steering Committee Session, extended	Steering Committee REDD+ Secretariat SINAC – FONAFIFO Number of Individuals: 21 (11 women, 10 men)	The preliminary BSP was consulted with FONAFIFO and SINAC. A weeklong window was open for comments. The participants, topics and agreements can be reviewed in meeting report No. 3-2019.
July 31, 2019	Monitoring Committee Session	Forest land smallholders, NGOs, Indigenous Peoples and members of academia Number of Individuals: 10 (3 women, 7 men)	The progress on the ERPA with the Carbon Fund was reported, including the issue of the BSP. After this meeting, the BSP was shared with the members of the committee. The participants, topics and agreements taken can be reviewed in meeting report No. 2-2019.

Initial versions of the BSP were disclosed on January 9, 2018 through Costa Rica's REDD+ website and direct emails to stakeholder representatives. The Advanced Draft of the BSP has been cleared by the World Bank and disclosed on the World Bank Group's external site.

Once the Advanced Draft of the Benefit Sharing Plan was approved, relevant stakeholders were consulted. A total of 11 consultation workshops were held, mostly virtually, with private landowners, non-governmental organizations,

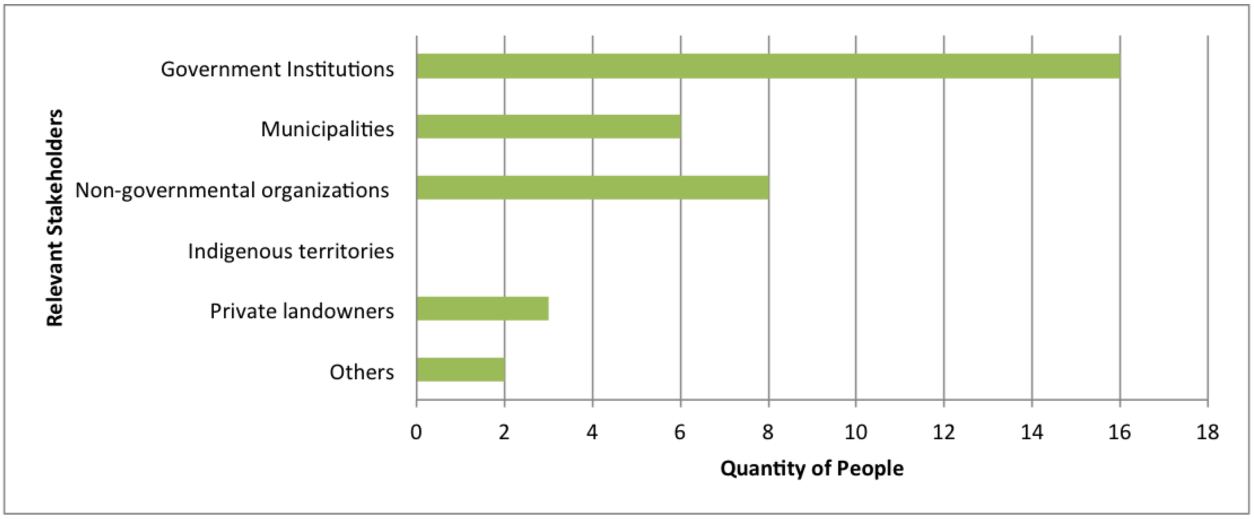
[100] The topics discussed in the "Workshop to Identify Elements for the Basis of the REDD+ Benefit Sharing Plan" can be found at the following link:
https://drive.google.com/open?id=1-OuzNdHVGu0UXAoJAIA70D78qKiyz8EN.

[101] The list of emails sent to disseminate the draft version of the BSP may be found in Annex 4 of the Advanced Draft of the BSP.

[102] The list of participants and the minutes of the BSP consultation and dissemination workshop with Indigenous Peoples can be accessed via the following links: https://drive.google.com/open?id=1y6TPWL XCPNR1Y8pyi4VjO-limuHujg3d and https://drive.google.com/open?id=1_89Oaaq A2-I7IT2U0mo0aFcS70GOQ-l3.

municipalities, and government institutions. The REDD+ Secretariat prepared an online survey for all sessions to collect feedback. Figure A2.1 breaks down participation in the survey by stakeholder group.

Figure A2.1 Institutions and organizations that participated in the completion of the Advanced Draft of the BSP survey



As illustrated in the figure above, Indigenous consultations are still pending and need to be finalized. Consultations on the Advanced Draft of the BSP with the 24 Indigenous territories are expected to be completed by the end of October 2021 so that the final BSP can be submitted to the FCPF by November 2021. The pending workshops with Indigenous leaders will address the issue of revenues from the sale of ERs, who benefits, what types of benefits are generated, the proposed distribution of benefits and the actions to be taken by public institutions with the reclaimed resources. The results and observations from consultations with other stakeholders have been already been discussed by the REDD+ Steering Committee. After the Indigenous consultations are concluded and systematized, the REDD+ Steering Committee will make its final decisions on the incorporation of relevant changes to the BSP before the final version is submitted to the FMT in November 2021.

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?

In February 2020, the World Bank completed a Financial Management (FM) Assessment of FUNBAM, which is responsible for the fiduciary aspects of the payment system of the Carbon Finance operation. The World Bank concluded that FUNBAM had limited FM arrangements, which could cause delays in implementation. The fiduciary risk rating was also considered substantial because of FUNBAM's lack of prior experience implementing World Bank financed projects, the complex implementation arrangements of the BSP and the lack of an operational manual to operate the BSP.

Since then, FUNBAM has successfully accomplished a series of mitigation measures suggested by the Bank to improve its FM capacity and effectively manage its responsibilities. FUNBAM's financial oversight functions have been strengthened to receive and administer ERPA payments. An administrative and financial unit within FUNBAM has been established to build its respective capacity—with hired professional and supporting staff in project, procurement, financial and contract management to effectively administer ERPA proceeds. A BSP operations manual detailing FM procedures has been developed and approved. Moreover, an automatic accounting system has been established and will be upgraded in 2021. However, additional administrative reinforcement is still needed and the World Bank will provide FUNBAM with FM training.

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

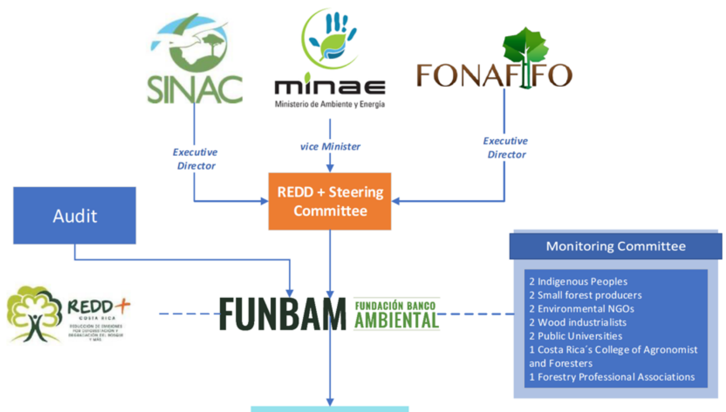
Not applicable, as this is the first reporting period.

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.

The agreed institutional arrangements under the BSP are in place. Figure A2.2 shows the governance structure at the national level for the implementation and monitoring of the BSP. Figure A2.3 illustrates the flow of funds to ensure implementing entities are appropriately resourced to carry out their respective responsibilities. The role and responsibility of implementing entities is briefly described below.

Figure A2.2 Governance of the BSP



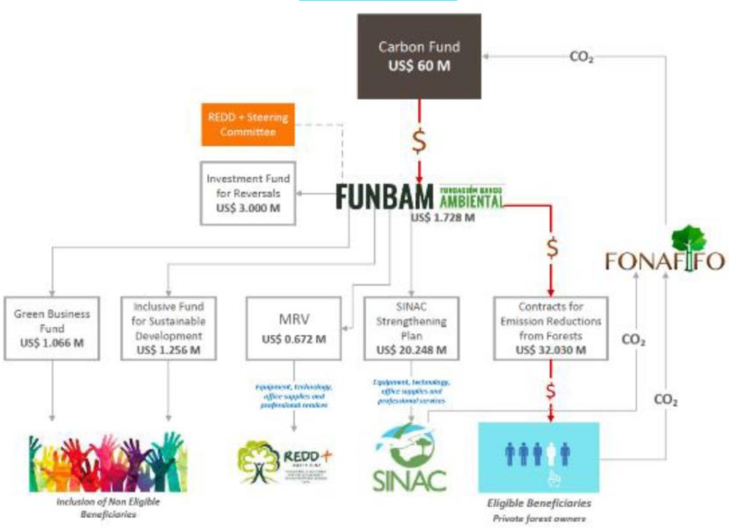


Figure A2.3 BSP Flow of Funds

<u>REDD+ Steering Committee</u>

The REDD+ Steering Committee was created by Decree 40464-MINAE and is comprised by the Executive Director of SINAC, the Executive Director of FONAFIFO, and the Deputy Minister of MINAE. Its function is the supervision and political direction of the REDD+ Secretariat, the negotiation of reductions and ensuring compliance with Costa Rica’s REDD+ Strategy.

<u>MINAE</u>

MINAE is the Program Entity that has signed the ERPA with the World Bank. The Republic of Costa Rica conferred authorization to the Minister of MINAE—through the Executive Decree 35669 MINAE Organic Regulations, Article 7 of the Ministry's Dispatch—to legally represent the country.

FUNBAM

ERPA proceeds will be received and administered by FUNBAM. FUNBAM was created by Law No. 8640 of 2008 with the objective to support Costa Rica in conserving biodiversity and ensuring the long-term sustainability of its PES program. One way FUNBAM does this is by administering the Fund for Sustainable Biodiversity (*Fondo de Biodiversidad Sostenible*, FBS), which was created with support from the World Bank and the Global Environment Facility under the Mainstreaming Market-Based Instruments for Environmental Management Project (P093384). The Administrative Board of FUNBAM consists of five members: i) the Minister or a representative of MINAE, ii) the Minister or a representative of the Ministry of Agriculture, iii) the Director or a representative of FONAFIFO, iv) the Director or a representative of SINAC and iv) a representative of the National Bank of Costa Rica as the Trustee of the FBS.

REDD+ Council of Directors

The REDD+ Council of Directors was established under Article 7 of the REDD+ Decree and is comprised of the Executive Director of SINAC, the Executive Director of FONAFIFO and the Vice Minister of Environment. To avoid a potential conflict of interest with MINAE as the Program Entity, the REDD+ Council of Directors will instruct FUNBAM on the amount of funds to be transferred to each Sub-Project Entity following the receipt of ERPA proceeds. FUNBAM will in turn execute such payments according to the instructions that have been issued.

Monitoring Committee

The main function of the Monitoring Committee is to ensure that different stakeholders comply with the REDD+ Strategy as long as there are resources for this purpose. The Monitoring Committee was established by Article 18 of Decree 40464-MINAE and is composed of the following: two representatives of Indigenous Peoples established in Costa Rica; two representatives of small forest producers, as defined in Article 2, Subsection “y” of the Regulations to the Forest Law Executive Decree 25721-MINAE and its amendments; two representatives of non-profit non-governmental organizations working in the environmental sector; two representatives of owners of primary industries that process wood in the country; two representatives of public universities that teach Forest Sciences; a representative of the Association of Agricultural Engineers; and one representative of the country’s professional forestry associations. The Monitoring Committee has been in operation since January 2019 and meets regularly, including to discuss the Advanced Draft of the BSP, which has already been consulted.

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

The Program Entity, MINAE, must demonstrate to the World Bank, prior to the first ER transfer, that actions related to fiduciary aspects have been complied with and adequate arrangements are in place. As the Program Entity, MINAE entered a Subsidiary Agreement with FUNBAM (the entity receiving the ER payments) satisfactory to the World Bank as a Condition of Effectiveness referenced in the ERPA to establish FUNBAM’s responsibilities related to financial oversight of the receipt and forwarding of Periodic Payments. A final version of this agreement has been shared with the FCPF.

The Condition of Effectiveness referenced in the ERPA regarding the endorsement and validation of the ERPAs by the Comptroller General of the Republic has also been completed in that the Comptroller General provided evidence that such an endorsement and validation is not necessary for an ERPA.

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.

Relevant stakeholders have a clear understanding of their obligations, roles and responsibilities associated with the BSP. The consultations described in Section 1.1 have served to both socialize the BSP and to communicate the roles and responsibilities of all stakeholders. Adding to this clear understanding is the fact that Costa Rican institutions have extensive experience in forestry-related benefit sharing. The country has been running a Payment for Environmental Services Program targeting private forest owners since 2017 and has generated a governance structure in which institutions, private forest owners and other relevant stakeholders are very clear about the responsibilities assumed.

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?

Section 1.2 describes the measures taken by FUNBAM to strengthen its financial management capabilities as a result of the World Bank's FM Assessment. These include: i) establishing an administrative financial management unit within FUNBAM; ii) setting up an accounting system to administer ERPA funds; and iii) developing a BSP operations manual to ensure adequate management and monitoring mechanisms over the funds.

When a payment under the ERPA is due (i.e., after successful verification of results), the World Bank (as trustee of the Carbon Fund) will receive a Transfer Form from MINAE (as the Program Entity), requesting such payments to be deposited into the Operational Account in US dollars under conditions acceptable to the World Bank. FUNBAM will receive and administer the funds related to the ERPA and will disburse them to Sub-Project Entities in accordance with the BSP. FUNBAM will open a main account exclusively for the management of ER payments, which includes independent sub-accounts for the CREF, SINAC Strengthening Plan, Investment Fund for Reversals, Inclusive Sustainable Development Fund, Green Business Fund and ER Program Implementation.

Transactions will be recorded following institutional accounting policies. FUNBAM will prepare and submit semi-annual BSP financial reports in US Dollars to the World Bank; on an annual basis, FUNBAM will prepare BSP financial statements that will include explanatory notes of resources administered which will be audited and submitted to the World Bank.

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.)

The following accountability mechanisms are in place and functional: a Feedback and Grievance Redress Mechanism, MIRI; independent third-party monitoring under process; and a third-party financial audit mechanism.

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.

The FGRM, MIRI, is functional and able to record and address feedback and grievances, including those related to the implementation of the BSP. MIRI operates through the Service Comptrollers of FONAFIFO and SINAC. The Service Comptroller's Offices are entities created by Costa Rican legislation as a mechanism to guarantee the rights of users of the services provided by public organizations and private companies that provide public services. Section X of the Retroactive Report 2018-2019 provides a detailed description and analysis of MIRI based on the reports of the FONAFIFO and SINAC comptrollers. The retroactive period reported 279 requests in 2018 and 183 in 2019, broken down by type in Table A1.7: queries, non-conformities, complaints, suggestions, and congratulations. All requests were addressed within an average of three days.

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

Prior to the first ER payment, the BSP budget will be incorporated in FUNBAM's budget, based on the input provided by the National REDD+ Secretariat. FUNBAM has been staffed with a financial specialist/accountant, treasury assistant and internal auditor with the appropriate skills and experience to be effective (see Section 1.2).

3. Status of Benefit Distribution

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

The section is intentionally left blank because no monetary and non-monetary benefits were distributed in the period between January 1, 2018 and December 31, 2019.

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 section is intentionally left blank because no beneficiary received benefits during the period between January 1, 2018 and December 31, 2019.

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

The section is intentionally left blank because no beneficiary received benefits during the period between January 1, 2018 and December 31, 2019. As a result, there was no need for 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.

Regarding the effectiveness of mechanisms for ensuring transparency and accountability during the implementation of the BSP, MIRI has been designed as an FGRM to receive and address relevant stakeholders' concerns. A series of information and training sessions held with Indigenous communities, groups of small and medium agroforestry producers, forest organizations and other stakeholders generated valuable inputs for the final design of the mechanism to ensure it fosters dialogue in the case of disagreements. A wide range of communication channels are available to make the instrument universally accessible: website, email, online chat, phone, participation fairs, on-site, SITADA and a suggestion box. The SIS was not yet operational during the retroactive period, but will provide information on how the safeguards will be treated and respected throughout the implementation of the ER Program to the public. Once ER Payments are received, all the benefits transferred will be disclosed on the SINIA website. [103] Moreover, because the REDD+ Secretariat and FUNBAM's Administrative Board are fully governmental, the inclusion of non-governmental stakeholders in the decision-making process for benefit sharing is done through the Monitoring

[103] Sistema Nacional de Información Ambiental de Costa Rica.

Committee. This is to support transparency and credibility and to reduce social risks in the implementation of the BSP. The Monitoring Committee includes representation from Indigenous Peoples, small forest producers, environmental NGOs, wood industrialists, public universities, academia and forestry professional associations.

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).

The section is intentionally left blank because no benefits sharing distributions took place in the period between January 1, 2018 and December 31, 2019.

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?

There will be several monitoring channels to verify how benefits are used and whether payments provide sufficient incentive or compensation to participate in program activities to change land use or reduce carbon emissions. The results of a technical assessment of the adequacy of the incentives in the retroactive period will be ready at the end of September 2021. The distribution mechanisms have been designed with the feedback of relevant stakeholders and under the supervision of a diverse Monitoring Committee to ensure the transparency and inclusivity necessary to be viewed as credible and trusted by beneficiaries.

The REDD+ Secretariat has made internal arrangements for monitoring each of the projects. SINAC will prepare an Implementation Plan for the funds, as well as periodic reports on their use. The Indigenous territory will prepare the Resource Execution Plan approved by the ADI Assembly, as well as implementation reports. The REDD+ Secretariat will monitor the CREFs through a geospatial database and against payments executed by FUNBAM. The REDD+ Secretariat will be responsible for compiling the information and sending the ER Monitoring Report for each monitoring event. The Program Entity, MINAE, will first monitor and report on the implementation of the BSP six months after the receipt of the first Periodic Payment and annually thereafter. Interim Progress Reports will describe progress made with the operation of the BSP at least annually. Supervision will also include regular World Bank implementation support missions (including virtual missions).

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?

In the period between January 1, 2018 and December 31, 2019, no benefit sharing distributions happened. However, the BSP has been designed and disseminated through a participatory process to diverse stakeholder groups in order to ensure that beneficiaries understand their continued obligations once benefit distribution has taken place and that there is no mismatch of expectations among beneficiaries regarding the nature and value of benefits accruing to them. All the information and consultation activities related to the BSP and the ER Program have been done in a form, manner and language understandable to relevant ER Program stakeholders in one or more convenient public locations and through accessible means. Announcements are communicated on the website, as well as on social media platforms and networks, to keep stakeholders up to date.

The Government recognizes that expectations are especially financial in nature. In order to manage risks that the current incentive is not sufficient, the Government has identified the Green Climate Fund (GCF) as a potential solution and is proposing merging the GCF and Carbon Fund funds to obtain a higher compensation per hectare.

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.

The application of safeguards instruments mitigates the social and environmental risks from the ER Program. Safeguards instruments will apply to activities implemented with the ER payments. The existing FGRM, MIRI, will also be used by individuals and communities who believe they are adversely affected by the initiatives. The REDD+ Secretariat will be responsible for ensuring compliance with the World Bank safeguards requirements of initiatives implemented with ER Payments.

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.

The BSP has been adapted based on the results of consultations and discussions held at the local and national levels, despite not being implemented in the ER MR period. The substantive change that has been approved is the aforementioned proposal to combine funds from the GCF and Carbon Fund to increase the compensation per hectare, and thus create a larger incentive for beneficiaries.

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?

The section is intentionally left blank because the BSP was not yet implemented in the period between January 1, 2018 and December 31, 2019.

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

As the BSP is an adaptive instrument, which is supported by all the safeguard instruments in use, conditions are created for the application of some measure that can reduce or eliminate any emerging risk that may occur. However, there are concerns about the risks associated with combining the GCF and Carbon Fund funds, which are managed separately by FONAFIFO and FUNBAM respectively.

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

Table A2.2 provides a timeline and outline of the BSP Action Plan.

Table A2.2 BSP Action Plan

Activity	Deadline	Status	Observation
Finalize consultation in Indigenous territories	No later than October 22, 2021	In process	Support is being provided by WB team to ensure that the systematization of the information happens in parallel.
Systematize the results of the consultation	In parallel to the consultations and completed no later than October 29, 2021	Pending	
Incorporation of relevant changes in the BSP, approval of the BSP by the Steering Committee and submission of final BSP to the FMT	No later than November 5, 2021	Pending	

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

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)

Costa Rica's National REDD+ Strategy aims to address the drivers of deforestation and forest degradation, improve forest management and conserve forest carbons stocks, thus contributing to climate change mitigation while achieving multiple other environmental and social non-carbon benefits, consistent with the REDD+ safeguards agreed under the UNFCCC.

Table 1 includes the list of indicators, based on data available in short to medium term, to measure the generation of the priority co-benefits identified in the Emission Reduction Program Document (ER-PD). These indicators were used to monitor the generation or enhancement of priority non-carbon benefits. Table 2 shows the description of the REDD+ benefits included in the Convergence Maps, used to estimate the non-carbon benefits generation.

Table 13 List of Identified Non-Carbon Benefits

Benefits of REDD+	Map of Convergence of multiple benefits			Indicators Details on activities for generation and enhancement
	Low-carbon agricultural production systems.	Forest conservation	Landscape Restoration	
Climate change mitigation		✓	✓	Number of hectares with REDD+ activities
Natural scenic beauty for tourism purposes		✓		Number of hectares with REDD+ activities in districts with areas of importance for tourism
Biodiversity Conservation		✓	✓	Number of hectares with REDD+ activities in biological corridors
Support to communities vulnerable to water stress	✓	✓	✓	Number of hectares with REDD+ activities in areas vulnerable to water stress
Potential for socioeconomic improvement	✓	✓	✓	Number of hectares with REDD+ activities in areas with low Social Development Index (less than 40 percent)
Control of soil loss by water erosion	✓	✓	✓	Number of hectares with REDD+ activities in areas at erosion risk
Potential for improving governance	✓	✓	✓	Number of institutions' staff who are responsible for natural resources management that have received training in REDD+
	✓			Number of REDD+ trainings for officials (MAG, MINAE, CIAgro) and organizations responsible for the implementation of Nationally Appropriate Mitigation Actions in the agriculture sector.

Table 14: Description of benefits of REDD+ included in the Convergence Maps.

Benefits of REDD+	Description of benefits included in the Convergence Maps		
	Low-carbon agricultural production systems.	Forest conservation	Landscape Restoration

Climate change mitigation		Tropical forests make up one of the largest reserves of forest carbon in the world. Its deforestation and degradation cause its release and its restoration as a sink. The density of carbon in biomass by land cover class is used as an indicator variable.	
Natural scenic beauty for tourism purposes		Nature-based tourism has the potential to generate income that promotes its conservation and improves local living conditions. The scenic beauty can encourage the flow of visitors to areas dedicated to this activity. The distribution of floors of international tourist demand is used as an indicator variable.	
Biodiversity Conservation		Tropical forests are the terrestrial ecosystems with the highest species richness, so their conservation would contribute to ensuring the protection of biodiversity in the long term. The richness of threatened forest species is used as an indicator variable.	
Support to communities vulnerable to water stress	Under certain conditions, tree cover contributes to maintaining a positive water balance, so increasing it through forest conservation, restoration and agroforestry practices could support communities living in areas vulnerable to water stress. The estimate of water production due to the increase in tree cover in areas vulnerable to water stress is used as the indicator variable.		
Potential for socioeconomic improvement	Forest conservation, restoration, and agroforestry have the potential to support local livelihoods and serve as an instrument to alleviate poverty since it can favor the provision of goods and services that contribute to family income and improve the quality of life in neighboring communities. The Social Development Index is used as an indicator variable.		
Control of soil loss by water erosion	The tree cover can retain the soil and protect land at risk from water erosion. The introduction and strengthening of agroforestry practices in agricultural areas could contribute to the provision of this benefit. The relative risk of water erosion is used as an indicator variable.		
Potential for improving governance	The implementation of REDD+ can promote improvements in the decision-making processes associated with the protection of tree cover since it brings with it a framework of safeguards that must be addressed and respected to reduce social and environmental risks that may arise from putting into practice. Consequently, the introduction and strengthening in the REDD + context could strengthen decision-making processes. The Euclidean distance to government offices with access to the Mechanism of Information, Feedback, and Non-conformities for Relevant Stakeholders of the ENREDD + (MIRI) is used as the indicator variable. (See section 3.2 for further details on capacity building process of REDD+)		

Monitoring generation of priority non-carbon benefits:

Costa Rica's National REDD+ Secretariat, with the support of the UN-REDD Programme, carried out in 2017 an analysis to evaluate the spatial convergence of multiple non-carbon benefits that could potentially be generated by the policies, actions and measures (PAMs) included in the National REDD+ Strategy.[104] The result of this analysis was the identification of key areas where REDD+ PAMs could contribute to maintaining and generating the benefits prioritized in the Forest Law (Nº 7575, 1996), the Law of Land Use, Management and Conservation (Nº 7779, 1998), as well as during the consultation process for the preparation of the National REDD+ Strategy. The three following multiple-benefit convergence maps were prepared, which show the results of the analysis (see figure 1):

A. **Map of convergence of multiple benefits from low-carbon agricultural production systems**: The country identified the potential convergence of multiple benefits in agricultural areas where the Emission Reduction program would promote the agroforestry practices. The benefits included in this analysis are: 1) support to vulnerable communities due to water stress, 2) potential for socio-economic improvement, 3) control of water erosion, and 4) potential for improved governance. This analysis is limited to the benefits considered as priorities and the availability of spatially explicit information used to indicate these benefits and its underlying limitations as highlighted in the report. Consequently, it is essential to note that agroforestry can provide other priority benefits not considered in this analysis, and that due to data limitations areas where no benefits have been identified could still be providing the prioritized benefits or others not included in the analysis. Implementing these practices in tropical production systems can, for example,

[104] García-Rangel, Shaenandhoa; Walcott, Judith; de Lamo, Xavier; Epple, Cordula; Miles; Lera; Kapos, Valerie; UN Environment World Conservation Monitoring Centre. (2017). Beneficios Múltiples De REDD+ en Costa Rica: Análisis Espaciales para apoyar la Toma de Decisiones. Costa Rica: ONU-REDD+. https://www.researchgate.net/publication/322697821_Beneficios_multiples_de_REDD_en_Costa_Rica_analisis_espaciales_para_apoyar_la_toma_de_decisiones

increase biomass density and, consequently, carbon sinks (Ávila et al. 2001[105]; Albrecht & Kandji 2003[106]; Montagnini & Nair 2004[107]).

B. **Map of convergence of multiple benefits from conservation incentives and sustainable management of forests**: This map shows the potential convergence of priority benefits in the forests of Costa Rica. It indicates where REDD+ actions for strengthening the conservation and sustainable management of primary forests could potentially maximize the provision of non-carbon benefits. The benefits included in this analysis are: 1) climate change mitigation, 2) scenic beauty for tourism purposes, 3) biodiversity conservation, 4) support for communities vulnerable to water stress, 5) potential for socioeconomic improvement, 6) water erosion control, and 7) potential for improved governance. This analysis is limited to the benefits considered as priorities and the availability of spatially explicit information used to indicate these benefits and its underlying limitations as highlighted in the report. Due to data limitations areas where no benefits have been identified could still be providing the prioritized benefits or others not included in the analysis.

C. **Map of convergence of multiple benefits from forest landscape and ecosystem restoration actions**: This map shows the potential convergence of prioritized benefits that could be secured through forest restoration in Costa Rica. The non-carbon benefits included in this analysis are: 1) climate change mitigation, 2) biodiversity conservation, 3) support for communities vulnerable to water stress, 4) potential for socioeconomic improvement, 5) water erosion control, and 6) potential for improved governance. This analysis is limited to the benefits considered as priorities and the availability of spatially explicit information used to indicate these benefits and its underlying limitations as highlighted in the report. Due to data limitations areas where no benefits have been identified could still be providing the prioritized benefits or others not included in the analysis.

Costa Rica based the monitoring of the generation or enhancement of priority non-carbon benefits on these three convergence maps. The country estimated the proportion of area under the ER Program for 2018-2019 (i.e. private and public lands) overlapping with the potential convergence of prioritized non-carbon benefits represented in each of the maps mentioned above. This proportion was calculated separately for each class/number of non-carbon benefits (from 1 up to 7), for all areas that have potential to provide at least one non-carbon benefit.

As part of the ER Program's entry process and to demonstrate ownership of emission reductions, the REDD+ Secretariat is building a geospatial database with information on the potential ER Program beneficiaries, including private forest owners, Indigenous peoples, SINAC, FONAFIFO, and other institutions administering State Natural Heritage. The REDD+ Secretariat has made a preliminary time/spatial overlay analysis considering i. Overdue Payment for Environmental Services (PES) contracts and rejected applications, ii. Geodatabase of forest lands owned by the State, iii. Geodatabase of active PES contracts, iv. Geodatabase of forests lands in Indigenous Territories, v. Geodatabase of forest lands supported by the Biodiversity Fund, and vi. Geodatabase of the first call of beneficiaries the Forest Emissions Reduction Mechanism (its acronym in Spanish is CREF). This analysis identified landowners' non-overlapped forest areas with CREF applications or expired agreements and applications that have not entered the Payment Program for Environmental Services (PPES).
The data collected for this geodatabase was reclassified as follows: 1) Program for Payment of Environmental Services for Agroforestry Systems. 2) Biodiversity Fund / Carbon Neutrality Program FONAFIFO and 3) State Natural Heritage. From this information and considering the maps of multiple-benefit production areas (Figure 1), the country estimated the proportion of land under the ER-Program 2018-2019 with potential to generate multiple-benefits. [108]

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[105] Ávila G., Jiménez F., Beer J., Gómez M., Ibrahim M. Storage, carbon sequestration and valuation of environmental services in agroforestry systems. Agroforestry in the Americas 80 (2001):32–35.
[106] Albrecht A., Kandji S. Carbon sequestration in tropical agroforestry systems. Agriculture, Ecosystems & Environment 99 (2003):15–27.
[107] Montagnini F., Nair P.K.R. Carbon sequestration: An underexploited environmental benefit of agroforestry systems. Agroforestry Systems 61 (2004):281–295.
[108] To carry out this analysis, each polygon was overlayed with the corresponding map to estimate the number of benefits generated on each property or on public land. Subsequently, the number of pixels of each level of convergence of benefits was extracted to calculate the coverage ratio of the ER-P.

Figure 5: Map A. Convergence of multiple benefits from low-carbon agricultural production systems. Map B. Convergence of multiple benefits produced with conservation incentives and sustainable management of forests. Map C. Convergence of multiple benefits from forest landscape and ecosystem restoration actions.

Generation of priority non-carbon benefits during the 2018-2019 period:

Tables 2, 3 and 4 show the estimate of the generation of priority non-carbon benefits in terms of each potential production area (i.e., total of pixels/area that produce at least one REDD+ benefit). It is essential to mention that this analysis does not include CREF beneficiaries because contracts are yet to be finalized, and the REDD+ Secretariat will finish this process by the beginning of the following year. The results obtained for each type of REDD+ action is summarized below:

<u>Forest conservation actions</u>: During the 2018-2019 period, Costa Rica achieved outstanding progress in prioritizing the implementation of conservation actions in areas with potential to generate non-carbon benefits. The country successfully focused conservation actions on potential multiple-benefit production areas, prioritizing the strata with a higher number of benefits. Costa Rica implemented forest conservation actions in 40% of forest lands that potentially producing at least one priority non-carbon benefit, and in almost 83% of forest lands that include potential to generate or enhance the seven prioritized non-carbon benefits. The locations with potential to deliver the higher number of non-carbon benefits had higher proportion of their land area included in conservation actions. The largest contributors in generating multiple benefits were the state's natural heritage and then the Payment for Environmental Services Program. This trend indicates that different forest conservation actions and the designing of protected areas during the 2018-2019 period aimed at maximizing multiple-benefit production (see table 2 and figure 2).

<u>Forest restoration actions</u>: During the 2018-2019 period, Costa Rica failed to significantly generate multiple benefits from forest restoration actions. REDD+ actions focused on forest restoration were implemented only in 1.2% of the areas with the potential to generate or enhance at least one non-carbon benefit. The main contributor to forest restoration is the Payment for Environmental Services Program. Restoration actions implemented between 2018-2019 were mainly concentrated on the locations with potential to deliver lower number of non-carbon benefits (1-3). Additional analysis is required to determine why it has not been possible to focus the restoration on the strata with the highest number of non-carbon benefits.

<u>Agroforestry practices</u>: During the 2018-2019 period, Costa Rica achieved significant progress in implementing agroforestry practices. In 10% of the areas that have the potential to produce at least one non-carbon benefit, agroforestry practices have been implemented. This implementation level achieved by the country is related to the importance of the Coffee Sector in Costa Rica. It is essential to mention that coffee producers in private lands were the major contributor of the achieved progress, and that they did not participate in the agroforestry practices promotion program included in the REDD + Strategy. Coffee is one of the most important commodity products in the country. In the same way that was observed for forest conservation actions, the country focused agroforestry practices on areas were potentially multiple benefits converged, prioritizing the strata with more benefits.

Therefore, locations identified with the potential to provide more non-carbon benefits had higher proportions of their land area included in the implementation of agroforestry practices.

It is important to note that the results of the analysis presented above are highly dependent on the quality of data and assumptions used to generate the information involved. As such, they are best used as relative indications of progress or challenges faced towards achieving the targets set out by Costa Rica under REDD+, rather than absolute values.

Table 15: Generation of priority non-carbon benefits from forest conservation actions included in the Costa Rica ER-Program, during the 2018-2019 period.

Number of priority non-carbon benefits from forest conservation	Proportion of potential multiple-benefit production area from forest conservation.	Biodiversity Fund / Carbon Neutrality Program FONAFIFO (%)	Program for Payment of Environmental Services (%)	State Natural Heritage (%)	Forest land protected for production of at least one non-carbon benefit (ha)
Non-critical forest lands for non-carbon benefit production	26.6%	0.1%	1.6%	14.0%	340,697
One non-carbon benefit	15.0%	0.2%	5.9%	8.9%	26,855
Two non-carbon benefit	22.4%	0.2%	7.7%	14.6%	121,249
Three non-carbon benefit	32.3%	0.2%	11.9%	20.2%	264,311
Four non-carbon benefit	47.3%	0.2%	13.6%	33.5%	341,390
Five non-carbon benefit	58.9%	0.4%	14.3%	44.3%	296,625
Six non-carbon benefit	72.1%	0.5%	12.0%	59.5%	101,809
Seven non-carbon benefit	82.8%	0.5%	25.1%	57.2%	3,091
Forest lands producing a least one non-carbon benefit	39.7%	0.2%	11.6%	27.9%	1,155,330

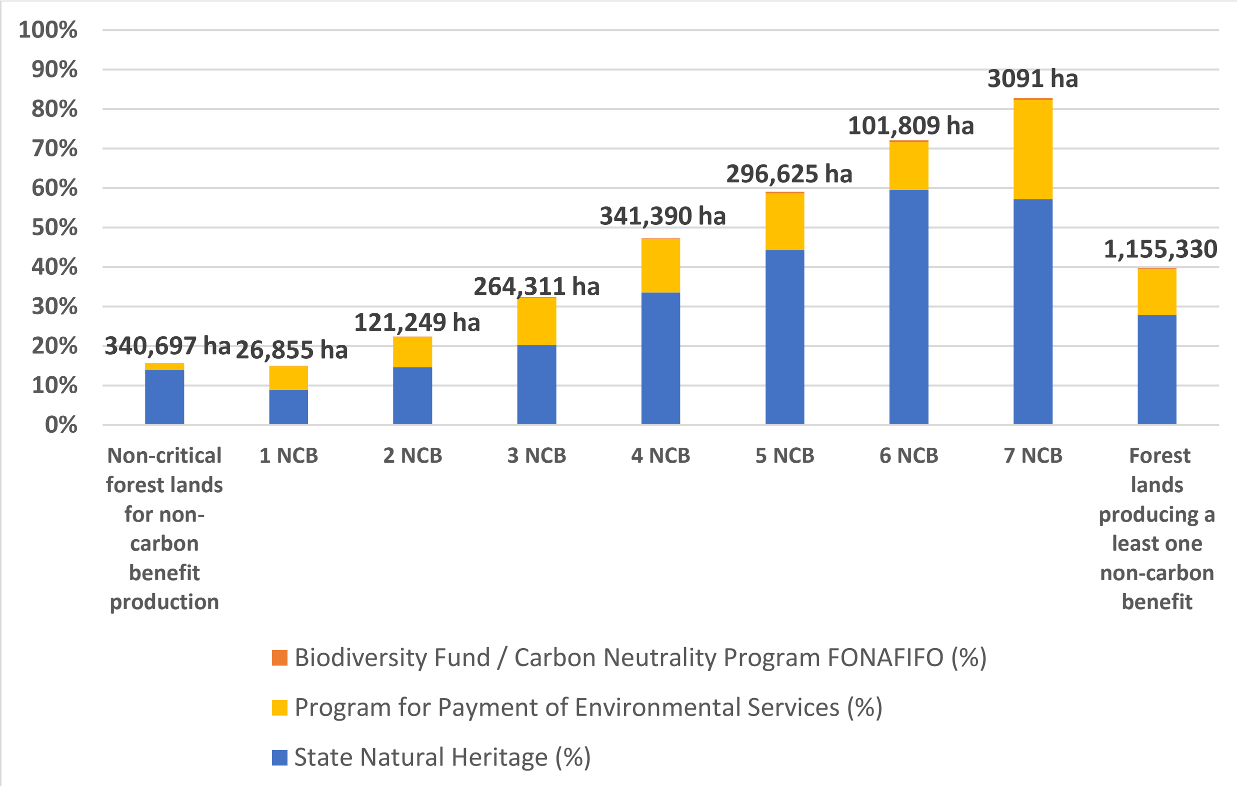

Figure 6. Generation of priority non-carbon benefits from forest conservation actions included in the Costa Rica ER-Program, during the 2018-2019 period.

Table 16. Generation of priority non-carbon benefits from forest restoration actions included in the Costa Rica ER-Program, during the 2018-2019 period.

Level of production of priority non-carbon benefits from forest restoration	Proportion of potential multiple-benefit production area from forest restoration	Biodiversity Fund / Carbon Neutrality Program FONAFIFO (%)	Program for Payment of Environmental Services (%)	State Natural Heritage (%)	Area of Forest restoration producing at least one non-carbon benefit (ha)
Non-critical forest lands for non-carbon benefit production	3.7%	0.1%	0.7%	0.0%	31,840
One non-carbon benefit	1.5%	0.2%	1.4%	0.0%	3,021
Two non-carbon benefit	1.3%	0.2%	1.1%	0.0%	4,227
Three non-carbon benefit	1.2%	0.4%	0.8%	0.0%	2,915
Four non-carbon benefit	0.3%	0.0%	0.3%	0.0%	305
Five non-carbon benefit	0.5%	0.1%	0.5%	0.0%	72
Six non-carbon benefit	0.0%	0.0%	0.0%	0.0%	-
Forest lands producing a least one non-carbon benefit	1.2%	0.2%	1.0%	0.0%	10,541

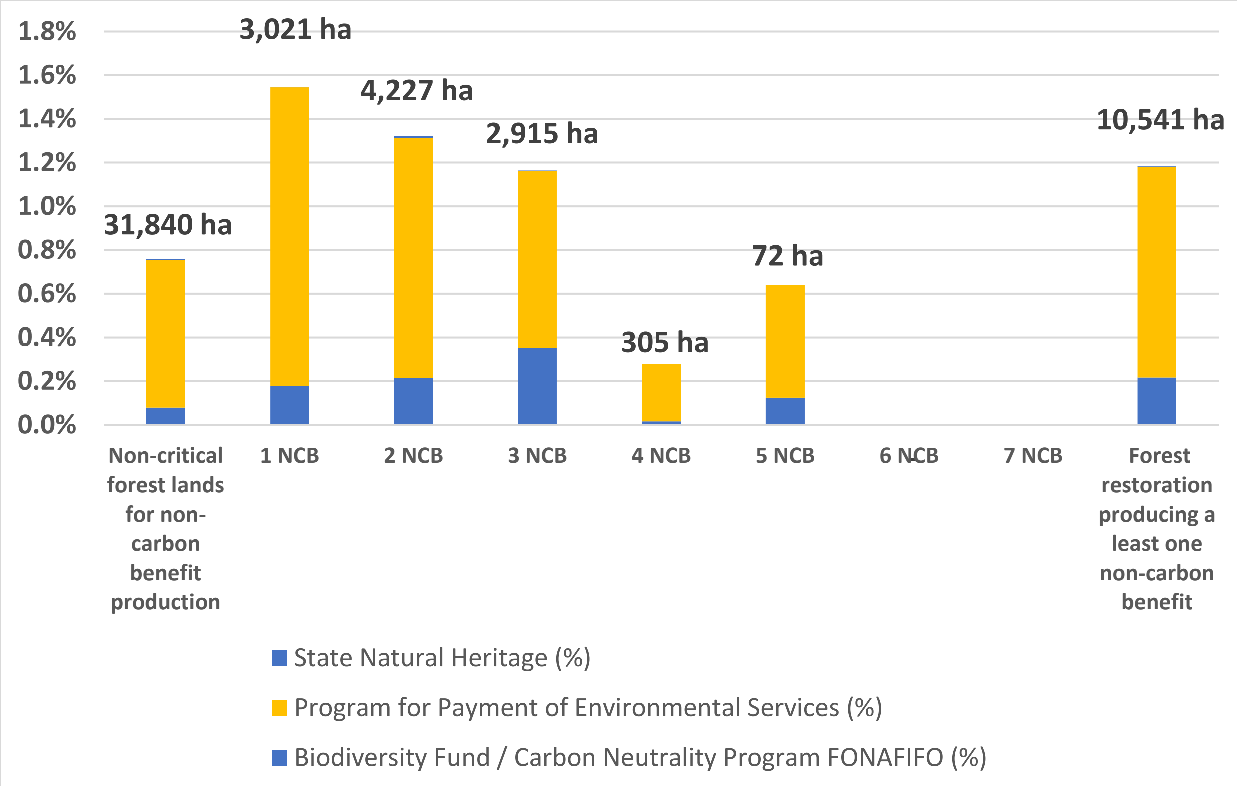

Figure 7. Generation of priority non-carbon benefits from forest restoration actions included in the Costa Rica ER-Program, during the 2018-2019 period.

Table 17. Generation of priority non-carbon benefits from implantation of Agroforestry practices included in the Costa Rica REDD+ Strategy, during the 2018-2019 period.

Level of production of priority non-carbon benefits from implementation of Agroforestry practices	Proportion of potential multiple-benefit production area from Agroforestry practices	Agroforestry Systems in Indigenous Territories (%)	Program for Payment of Environmental Services (%)	Coffee producers (%)	Area of Agroforestry practices producing at least one non-carbon benefit (ha)
Non-critical forest lands for non-carbon benefit production	10.4%	7.5%	0.0%	0.4%	300,016
One non-carbon benefit	6.1%	2.9%	0.1%	3.1%	52,877
Two non-carbon benefit	19.2%	6.0%	0.1%	13.0%	61,855
Three non-carbon benefit	27.3%	10.0%	2.4%	14.9%	17,704
Four non-carbon benefit	24.1%	10.5%	0.1%	13.5%	1,148
Agroforestry systems producing a least one non-carbon benefit	10.6%	4.1%	0.2%	6.3%	133,584

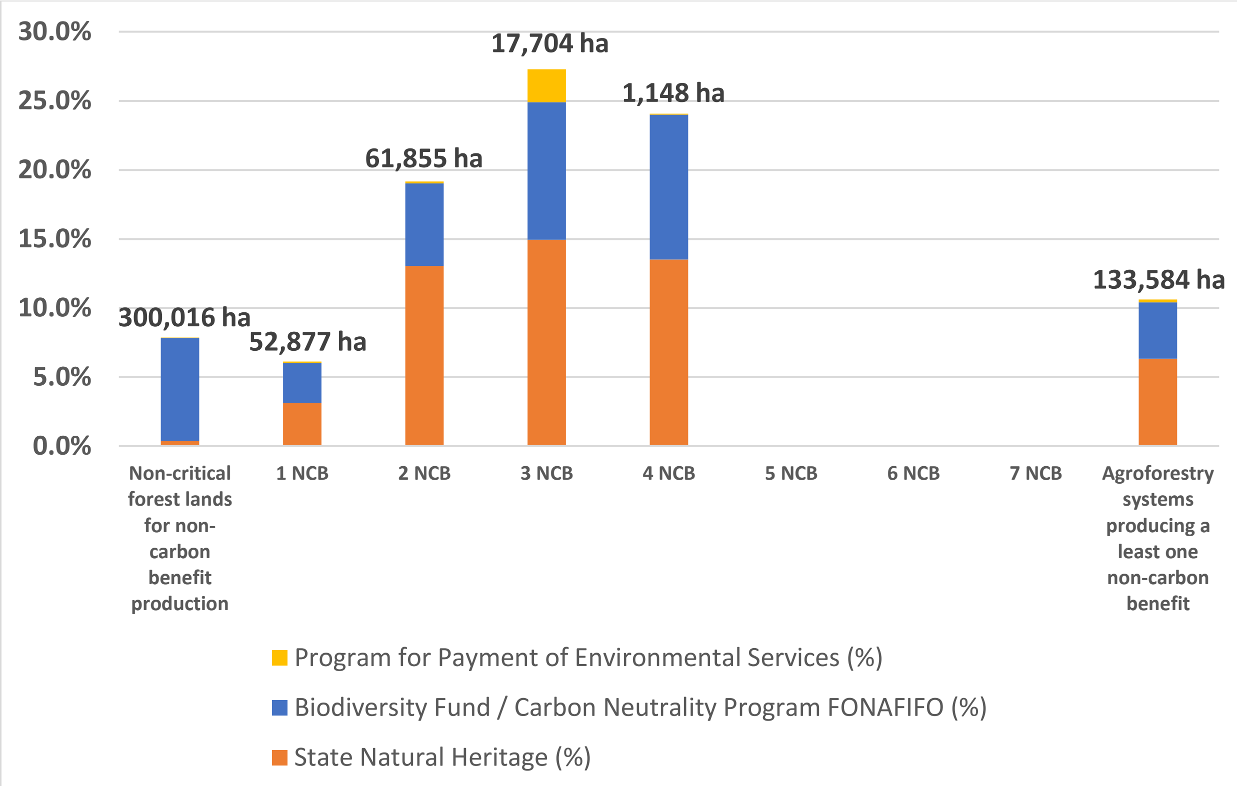

Figure 8. Generation of priority non-carbon benefits from implantation of Agroforestry practices included in the Costa Rica REDD+ Strategy, during the 2018-2019 period.

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)?

The ER Program will improve beneficiaries' livelihoods by reducing soil erosion, increasing timber and non-timber products, improving hydrological services, and strengthening adaptation to climate change. The National REDD+ Strategy will support forest cover improvements and forest health that in turn will bring associated co-benefits not only as a sink for carbon, but also for watershed protection, provision of important (biodiversity) habitats, provision of a sustainable source of non-timber forest products, and support of other forest-based livelihoods that are essential components of landscape resilience in the face of climate change (see section 1, table 1).

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)?

The ER Program seeks to strengthen the ASPs, which are strategically located to create biological corridors, protect high-conservation value forests, and avoid the loss of key species, to guarantee the conservation of critical biodiversity. Biodiversity maintenance has also been strengthened by improved forest fire management and by increasing incentives for forest conservation and sustainable forest management through the development of a more inclusive PES Program (see section 1, table 1).

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?

The ER Program is implemented in the continental territory of the country. Costa Rica has 1,538,000 ha under protection distributed in several management categories (see table 5). The area has not changed during this monitoring period 2018-2019.

Table 18. Protected Areas in Costa Rica during the 2018-2019 period.

Management category	Surface (ha)
Wetlands	36,615
National Monuments	230
National Parks	810,955
National Wildlife Refuge	289,539
Biological Reserve	32,803
Forest reserve	215,252
Absolute Nature Reserve	3,113
Protective Zone	149,494
Total area	1,538,000

Re/afforestation and restoration

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

Total reforested and restored area in the reporting period is 4,174 ha.

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$

The program budget has not changed. The budget presented initially in the ER-PD to finance the Payment for Environmental Services and cover the operating costs of SINAC during the 2018-2019 period was US$ 285,130,936. Costa Rica was able to fund 61% of the estimated budget.

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:

Costa Rica expended US$172,785,822 during 2018 and 2019 in the implementation of the ER-Program. The primary funding source is Public (national budget, fossil fuel tax, and water-canon). The country complemented ER-P's budget with private funding from conservation initiatives such as BN Servibanca Green Card and the EcoMarchamo. Table 7 details the financing received. The figures are in dollars, calculated with the Central Bank of Costa Rica average dollar price for the 2018-2019 period.

Table 7. Amount of finance received in support of the development and delivery of the ER Program.

Amount (US$)	**Source** (e.g. FCPF, FIP, name of gov't department)	**Date committed** (MM/YY)	**Public or private finance?**	**ERP, grant, loan, equity or other?**
$ 106,249,019	SINAC / National budget	Jan/2018-Dec/2019	Public	Other
$ 59,425,879	FONAFIFO/ Fossil Fuel Tax	Jan/2018-Dec/2019	Public	Other
$ 4,444,463	FONAFIFO / Water-canon	Jan/2018-Dec/2020	Public	Other
$ 1,484,781	FONAFIFO / Other sources	Jan/2018-Dec/2022	Public	Grant
$ 809,638	FONAFIFO / Costa Rican carbon units program	Jan/2018-Dec/2021	Private	Other
$ 352,229	FUNBAM / Trust Fund for Sustainable Biodversity - BN Servibanca Green card	Jan/2018-Dec/2023	Private	Other
$ 19,812	FUNBAM / Trust Fund for Sustainable Biodversity - EcoMarchamo	Jan/2018-Dec/2024	Private	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?

Costa Rica has not received payments for Emission Reductions produced during the 2018-2019 period, in addition to those committed by the Carbon Fund.

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)

No formal partnerships were established between the CF program and private sector entities in the reporting period.

3. Other Non-Carbon benefits and additional information

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.

No policy developments were made in the reporting period. In terms of approach, the ER Program is focused on increasing the impact of public policies that have proven successful in the last 20 years of implementing the national Forestry Law. The ER Program heavily relies on the prohibition of converting forests to other land uses, but also seeks to strengthen the Protected Wildlife Areas System to guarantee the conservation of critical biodiversity and the PES Program as a policy instrument to guarantee forest conservation and carbon stock enhancement through reforestation, tree plantations, agroforestry, and silvopastoral systems. Enhancement of the PES Program supports the active participation of forest organizations, Indigenous communities, and small agroforestry producers along with the promotion of productive activities in the sector and work opportunities in rural areas.

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.

With the support of different donors, the country provided capacity-building opportunities to officers of Costa Rican institutions to monitor land-use and land-use change. The Ministry of Environment organized twelve training workshops during the 2018-2019 period (see table 6). Also, the REDD Secretariat provided capacity-building opportunities to increase the participation capacities of the stakeholders of the REDD+ Strategy. The REDD+ Secretariat organized these events during the 2018-2019 period (see table 7).

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.

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ANNEX 4: CARBON ACCOUNTING - ADDENDUM TO THE ERPD

Technical corrections

Technical corrections included in this annex are not related to any change to policy and design decisions that could affect the Reference Level (carbon pools and gases, GHG sources, reference period, forest definition, REDD+ activities, Accounting Area, forest types, and REDD+ activities).

The country has replaced emission/removal factors for degradation by higher precision EF based on additional sample plots and corrected an error in the canopy cover change database during the identification of very degraded forests. Paragraph 3 positive list of the Guideline on the application of Methodological Framework Number 2 includes these technical corrections. Costa Rica has updated the FREL/FRL by recalculating the forest degradation emissions, as follows:

a. Increasing the number of field observations, following the methodology used in the NFI to determine aboveground biomass in 100 temporary degradation plots covering all forest types (i.e., wet and rain forests, moist forests, dry forests, mangroves, and palm forests). These new data were integrated into aboveground biomass vs. canopy cover models used to develop new degradation emission factors.
b. Updating the degradation categories in the aboveground biomass vs. canopy cover models as: intact forests have a cover of 85-100%, degraded forests have a cover of 60-85%, and very degraded forests a cover of 30-59%. Forest areas that went from intact to degraded, intact to very degraded, or degraded to very degraded (in terms of their canopy cover) during the reference period (1998-2011) were classified as degraded, whereas primary forest areas that went from very degraded to degraded, very degraded to intact, or degraded to intact were identified as forest enhancement areas.
c. An error was corrected in the database identifying forests classified as previously degraded. Prior to this correction, forests with a canopy cover of between 0% and 59% were classified as very degraded. To account for the fact that areas with less than 30% canopy cover are identified as non-forests, this classification was corrected to only include forests with a canopy cover between 59% and 30%.
d. Further, the methodology to estimate total uncertainty was updated as the previous approach of estimating the final confidence interval of the final distribution of Monte Carlo simulations was deemed to have led to unrealistically low values.

Detailed information about these updates is provided below (sections 1 and 2 of this Annex).

Summary of technical corrections

Degradation emission factors:
Degradation emission factors were updated based on the updated data obtained in 2018 from the 100 plots established to assess forest degradation in the country. Previously, to estimate emissions per hectare of degraded forest, linear models of the relationship between crown cover and aboveground biomass had been used for different forest types: very moist and rain forests (BMHP), moist forests (BH), dry forests (BS), mangroves (M), and palms (P).

With the new data (from 2018), it was possible to improve the analysis. In particular, the average ratio between aboveground biomass and canopy cover was estimated for each forest type (Table 3). It was decided to use this methodology instead of the previous methodology (applying an equation of the linear relationship between crown cover and biomass), because the results of the other methodology showed very weak relationships in several of the forest types. In contrast, by applying an average fixed relationship between aboveground biomass and crown cover, their associated uncertainties were much lower. In other words, this new methodology better explains biomass losses. As in the previous case, biomass was converted to carbon by a factor of 0.47 and to CO_2 by a factor of 44/12. The uncertainties were calculated from the standard deviations of the identified relationships.

Table 3. Ratio aboveground biomass to percent canopy cover

	Ratio Aboveground biomass (t CO_2e ha^{-1})/ % canopy cover	Uncertainty (%)
Wet and rain forest (BMHP)	5.03	16%
Moist forests (BH)	3.86	22%
Dry forests (BS)	3.47	24%
Mangroves (M)	3.19	32%
Palm forests (P)	4.26	37%

As a result, emissions due to annual losses of aboveground biomass from identified canopy cover changes were estimated. For example, if the canopy cover in a dry forest area was reduced by 20%, it was estimated that the biomass in this area was reduced by 69.4 t CO_2e per hectare (20*3.47 = 69.4 t CO_2e).

Corrections to the area of forests classified as severely degraded:
An error was corrected in the database identifying forests classified as previously degraded. Prior to this correction, forests with a canopy cover of between 0% and 59% were classified as very degraded. To account for the fact that areas with less than 30% canopy cover are identified as non-forests, this classification was corrected to only include forests with a canopy cover between 59% and 30%. This, in turn, reduced the area identified as being degraded as well as the area identified as being regenerated during the monitoring period (Table 4).

Table 4. Degraded and regenerated estimated areas prior to and post corrections

	Prior to corrections		Post corrections	
	Annual degraded area (ha)	Annual regenerated area (ha)	Annual degraded area (ha)	Annual regenerated area (ha)
Wet and rain forest (BMHP)	9,971	41,531	4,137	6,114
Moist forests (BH)	35,172	10,324	5,930	4,781
Dry forests (BS)	2,080	275	368	92
Mangroves (M)	-	1,060		46
Palm forests (P)	2,041	432		276
Total	49,264	53,621	10,435	11,308

Removal of accounting of degradation and regeneration within different degradation class:
Previously, all emissions and removals were calculated based on changes in canopy cover including within different degradation classes (i.e., within intact forests that remain intact, within degraded forests that remain degraded, and within very degraded forests that remain very degraded). The emissions and removals within these forest classes, however, were relatively small and their associated uncertainty were high. As a result, they were excluded, and only carbon fluxes between different degradation classes remained.

Updates to the calculations of final uncertainty:
To estimate the final uncertainties of emissions and removals from different REDD+ activities and the final uncertainty of net emissions from all these activities, the percentile method, in which the confidence interval was estimated by subtracting the 5^{th} percentile value from the 95^{th} percentile value of the final distribution of the Monte Carlo simulations, was applied instead of the bootstrapping method. This change was made because, since the most recent version of the ERPD, the bootstrapping method has been deemed to greatly underestimate uncertainty.

Start Date of the Crediting Period

According to the Emission Reductions Payment Agreement the Start Date of the Crediting Period is 1st January of 2018.

7. CARBON POOLS, SOURCES AND SINKS

7.1 Description of Sources and Sinks selected

Sources/Sinks	Included?	Justification/Explanation
Emissions from deforestation	Yes	According to the National GHG inventory and for purposes of the RL, deforestation was defined as Forest land converted to other land use categories in the year of conversion. Activity data for deforestation was obtained from a multi-year land use change time series. It is important to note that tree plantations are part of the sub-category "secondary forests", which are included in the Forest land category. Changes from secondary forests to other land uses are thus regarded as deforestation. If the land is allowed to regenerate back to a secondary forest or is planted again as part of a timber production regime, the event is recorded as conversion to Forest land at year 4 or 8, as appropriate. Emissions from deforestation were estimated assuming constant C stocks over time in primary Forest land and variable C stocks, according to forest age in secondary Forest land.
Emissions from forest degradation	Yes	Emissions from forest degradation were estimated using a visual assessment canopy cover density on high resolution images, which classified primary forest areas as intact, degraded, and very degraded depending on canopy cover in the forests remaining forest land.
Enhancement of forest carbon stocks	Yes	Removals were estimated in secondary forest and forest remaining forest as follows: Secondary forest: It was assumed that Forest land in transition complies with the definition of forest at years 4 and 8, for wet and dry forests, respectively (see Section 4.1. of the ER-PD for more details on land classification). C stock enhancement in secondary[109] Forest land remaining Forest land was estimated using growth models developed in Costa Rica (Cifuentes, 2008) [110]. These models estimate C stocks as a function of age. Cifuentes' equations were applied by determining the age of the forest in the year of the conversion and tracking forest age along the AD time series (more details are presented in Section 4.4 of the ER-PD). Forest remaining forest: Removals from forest enhancements in forest remaining forest is estimated using a visual assessment of canopy cover density on high resolution images (using the same methodology as that used to estimate emissions from forest degradation). As a conservative measurement, when a primary forest was detected to have increased in canopy cover, the increase in C stock was considered to be from secondary forest rather than primary forest regrowth.

109 The term "secondary" refers to forests that regenerated from previously disturbed land. Secondary forests were completely cleared for agricultural production or due to natural disturbance events. The term "secondary" is helpful to distinguish these Forest lands from primary Forest lands, which are non-managed.

110 Cifuentes, M. 2008. Aboveground Biomass and Ecosystem Carbon Pools in Tropical Secondary Forests Growing in Six Life Zones of Costa Rica. Oregon State University. School of Environmental Sciences. 2008. 195 p.

Sources/Sinks	Included?	Justification/Explanation
Conservation of forest C stocks	No	Not applicable.
Sustainable management of forests	No	Emissions/removals associated with the sustainable management of forests (SMF) are excluded. The country estimated the annual emissions due to SFM in about 44,729[111] tCO_2-e yr^{-1}, and represent 1.7% of the yearly net emissions observed during the Reference Period (FREL/FRL 2,585,717 tCO_2-e yr^{-1}); therefore, it is considered non-significant source emissions. It is important to note that the total area under forest management in Costa Rica is minimal (<500 ha yr-1). Additionally, silvicultural practices are not stand-replacing but remove partial timber volumes every 15 years.

7.2 Description of carbon pools and greenhouse gases selected

The following Carbon Pools and greenhouse gases will be accounted as part of the ER Program. The ER Program accounts all significant Carbon Pools and greenhouse gases except Soil Organic Carbon (SOC) due to the lack of sufficient reliable data available to estimate emission factors.

Regarding the SOC carbon pool, it is essential to mention that Costa Rica is committed to improve SOC data. The country aims to increase the organic carbon content of soils and make markets pay for ecological services through the RECSOIL program. The initiative is still on track after being announced at the end of 2020. RECSOIL is an FAO project designed to address the key challenges humanity faces today within an enabling framework integrated by a series of institutions and commitments related to climate change and sustainability. The program's main objective is to support and improve the national and regional GHG mitigation and carbon sequestration initiatives. This will be achieved by establishing a robust methodology that allows carbon credits to be traded.

Carbon Pools	Selected?	Justification/Explanation
Above Ground Biomass (AGB)	Included	Major carbon pool impacted by all REDD+ program activities. Data is derived from the National Forest Inventory[112].
Below Ground Biomass (BGB)	Included	Major carbon pool impacted by mortality of trees accounted under deforestation, and growth of trees accounted under carbon stock enhancements from reforestation. Data is derived from the National Forest Inventory.
Dead Wood	Included	Deforestation has a negative impact on this pool, whereas reforestation has a positive impact. Thus, it is included because reliable country-specific data exists. Data is derived from the National Forest Inventory.
Litter	Included	Deforestation has a negative impact on this pool, whereas reforestation has a positive impact. Thus, it is included because reliable country-specific data exists. Data is derived from the National Forest Inventory.
Soil Organic Carbon (SOC), including peat	Excluded	This pool was excluded from the reference level because of the lack of sufficient reliable data available to estimate emission factors. Soil carbon may increase due to implementation of REDD+ activities such as carbon stock enhancements and conservation, reductions in deforestation and improved sustainable forest management, and thus resulting in conservative estimate for such activities.

[111] Winrock International. (2018). Sustainable Forest Management Reference Level for Costa Rica. Retrieved from https://drive.google.com/file/d/1yUxQEm3dN6F0jHAfWdPGljqfL_r1R6Cn/view?usp=sharing

[112] Aboveground biomass data from the National Forest Inventory used to estimate deforestation can be accessed at the following link: https://docs.google.com/spreadsheets/d/1-0ov5b9_byzuBmpzrS7MdUXWFvrwCiQE/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true

GHG	Selected?	Justification/Explanation
CO_2	Yes	The ER Program shall always account for CO_2 emissions and removals
CH_4	No	CH_4 and N_2O are important GHG released during biomass burning, a common method to eliminate residues after deforestation in Costa Rica (i.e. slash and burn). This pool, however, is excluded because this activity was banned after 1997, and the country considers it rarely occurs nowadays. Emissions from natural fires are not included in the accounting.
N_2O	No	

8 REFERENCE LEVEL

8.1 Reference Period

The Reference Period proposed in the ER-PD has not changed, it is 1998-2011.

Start date of the Reference Period (*1st January 1998*): 1997 is the year when the current Forestry Law was passed, including key forest policy, instruments and mechanisms (*e.g.* PES). 1998 is the closest date to 1997 for which Costa Rica has a map (please see previous footnote). Selecting 1998 as the base year of the historical reference period allows for the consideration of emission reductions that have resulted from the implementation of the current Forest Law. Because of this, the reference level can be used as a benchmark to measure emission reductions that are "additional" to the normal performance of current forest policies and programs. This date was strategically selected to show the impact of the Forestry Law and has an important role in the FREL/FRL to be submitted to the UNFCCC.

End of the Reference Period (*31st December 2011*): according to Costa Rica's R-PP and ER-PIN[113], the country's National REDD+ Strategy began implementation in 2010. However, given that for 2009 Costa Rica does not have a map[114], the TAP recommended that Costa Rica selected the year 2011 instead to comply with the CF-MF. Costa Rica followed the TAP's recommendation.

8.2 Forest definition used in the construction of the Reference Level

The definition of "forest" used in the construction of the proposed FREL is:

- **Minimum area: 1.00 ha**
- **Minimum forest canopy cover: 30%**
- **Minimum height of trees: 5.00 m**

This definition is consistent with the forest definition reported by Costa Rica under the Clean Development Mechanism (CDM) and is also consistent with the forest definition used in the context of the national GHG inventory. However, this definition is not consistent with Costa Rica's reports to FAO's Forest Resources Assessment (FRA). Under FAO-FRA, Costa Rica defines "forest" as:

- Minimum area: 0.50 ha
- Minimum forest canopy cover: 10%
- Minimum height of trees: 5.00 m

[113] Approved by the Carbon Fund in its resolution CFM/5/2012/1, which acknowledged the high quality of the ER-PIN (para. 1) and granted additional financing to move towards the ER-P (para. 2 and 3). In addition, the annex of the resolution identified key issues, these do not include an objection to the start of the National REDD+ Strategy or the ER-P in 2010.

[114] According to the CF's TAP, the IPCC approach 3 included in **indicator 11.1** of the CF-MF requires countries to have spatially explicit information or a map. Costa Rica challenged this interpretation but decided to follow the TAP's recommendation to shift the end-date of the historical reference period to 2011.

Costa Rica deemed more appropriate to maintain consistency in all its GHG-related reports and therefore decided that using the definition already applied in the context of the national GHG inventory and the CDM would be more appropriate in the context of the REDD+ than using the definition applied in FAO´s FRA.

Additionally, article 3 of Costa Rica's Forestry Law 7575 defines "forest" as a "*Native or indigenous ecosystem, intervened or not, regenerated by natural succession or other forestry techniques that occupies a surface of two or more hectares, characterized by the presence of mature trees of different ages, species and appearance, with one or more canopies covering over seventy percent (70%) of the area and with more than sixty trees per hectare with a diameter at breast height (dbh) of more than fifteen centimeters*". This definition translates to:

- Minimum area: 2.00 ha
- Minimum forest canopy cover: 70%
- Minimum height of trees: *N.A.*
- Minimum number of trees: 60 per hectare (with a diameter of at least 15 cm at breast height)

Although these definitions are not totally consistent, the definition of "forest" used in the context of REDD+ is broader and largely includes the definition in the law. In the context of the National REDD+ Strategy and the relevant national legislation, the definition of "forest" in the law is applicable for domestic purposes.

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

This section describes method used for calculating the average annual historical emissions over the Reference Period as described in the ER-PD, including an update on the methods for forests remaining forests requested by the FCPF Carbon Fund[115] (see Section 1 of Annex 4, "Technical corrections").

REDD+ Program area:
The jurisdiction of the national REDD+ program includes the entire continental territory of Costa Rica, with an area of approximately 51,000 km^2 (over 5 million hectares), which excludes Cocos Island. Cocos Island has been excluded because it is inhabited solely by park rangers, distant from Costa Rica's continental territory and therefore not prone to potential REDD+ activities displacements, and is not subject to anthropogenic intervention. Areas classified as unknown with no available data due to cloud cover (2.26% of the total territory), and areas of high geological risk (0.03% of the total territory) or associated to river-meandering (0.33% of the total territory) were also excluded. Overall, the total excluded area is equivalent to 2.61% of the country, and there is no evidence of any other forest areas (beyond those on Cocos Island) that could be systematically excluded from the land use/land cover map as unmanaged. Costa Rica does not expect additional areas to be excluded in the future due to gaps in land use information, given the increasing availability of global forest cover data.

Land Cover Maps:
Five forest categories were defined, all of them further stratified into Primary and Secondary Forests: Wet and Rain Forests, Moist Forests, Dry Forests, Mangroves, and Palm Forests. The following maps were used for the construction of activity data time series of these five categories:

- remote sensing data from four generations of Landsat; a "Life Zones"[116] map used to stratify Forests into Wet and Rain Forests, Moist Forests, and Dry Forests;
- ancillary maps to edit the remote sensing data for the Primary and Secondary Forest stratification of the five forest categories.

[115] Resolution CFM/14/2016/2. Selection of Emission Reductions Program Document of Costa Rica into the Portfolio of the Carbon Fund of the FCPF.
[116] Holdridge, L.R., 1966. The Life Zone System, Adansonia VI, 2: 199-203.

Satellite images were pre-processed to minimize cloud coverage gaps, using more than one image from the same year and season, and global data sources (e.g. Global Forest Change project[117]) to fill satellite information. When necessary, excluding areas covered by clouds in a given year was considered the best available solution. For the image pre-processing, Costa Rica is registering images to a common system of coordinates (CTRM05) with mean quadratic error of less than one pixel (i.e. 30 m) and maximum of two pixels and normalizing them radiometrically to minimize differences between images due to atmospheric conditions. Forest categories were classified using the Random Forest classifier[118]. Images were post-processed to a minimum mapping unit to comply with the minimum area for forest definition (i.e. 1 ha) and edited manually to decrease high classification errors and improve land use mapping. The ER-PD describes the following manual edits:

(1) merge the Forest Plantation with the Forest Land category because Forest Plantation presented a very high classification error;
(2) estimate Coffee Plantations from available government ancillary maps and define "potential" Coffee Plantations in all areas mapped based on elevation and location;
(3) create a mask for all potential areas of Mangroves and Palm Forests to reclassify forest areas as either Mangroves or Palm Forests, given that Mangroves and Palm Forests have very specific soil conditions and conversion from or to other forest types is highly unlikely;
(4) create a mask for Páramo to identify, based on elevation, the forest areas that need to be reclassified as Páramo.

Activity Data:
To calculate the average annual historical emissions over the reference period, Costa Rica followed an activity-based approach that accounts for emissions/removals from land use change activities (deforestation and reforestation). Under this approach, emissions and removals were estimated based on gross activity data that was spatially explicit, and on net emission factors. Activity data was entered in land use matrices (see Figure 5) to ensure representation of all land use transitions and avoid double counting or omitting emissions and removals and allowing the application of net emission factors for unique land use change conversions[119].

Accounting spatially-explicit gross activity data was possible thanks to a 1986-2013 time series specifically designed for REDD+ to ensure methodological consistency with the national GHG inventory. This time series was developed at the national level with land use maps derived from Landsat imagery. The maps, however, did not allow for differentiating between forest plantations and secondary forests in the baseline.

Figure 5. Simplified land use change matrix illustrating logic to define REDD+ activities in Costa Rica. Modified from: FREL/FRL Submission to the UNFCCC Secretariat, 2016. MINAE, Costa Rica.

	FL	LCFL	CL	GL	SL	WL	OL
FL	*CO*	*NA*	*DF.1*	*DF.1*	*DF.1*	*DF.1*	*DF.1*
LCFL	*EC.3*	*EC.2*	*DF.2*	*DF.2*	*DF.2*	*DF.2*	*DF.2*
CL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
GL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
SL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
WL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
OL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*

***FL**, Forest Land; **LCFL**, Land Converted to Forest Land; **CL**, Cropland, GL, Grassland; **SL**, Settlements; **WL**, Wetlands; **OL**, Other Land; **CO**, Conservation of forest C stocks; **EC**, Enhancements of forest C stocks (.1, EC in conversions of non-forest land to forest land; .2, EC in LCFL remaining LCFL; .3, EC in LCFL converting to FL); **DF**, Deforestation (.1, DF of old-growth forests; .2, DF of secondary forests); **NA**, Not Applicable in the REDD+ context.*

[117] Hansen et al. 2013; available at: https://earthenginepartners.appspot.com/science-2013-global-forest
[118] Breiman, L., 2001. Random Forests. Machine Learning 45 (5-3): link.springer.com/article/10.1023/A%3A1010933404324
[119] Forest reference emission level/forest reference level. Submission to the UNFCCC Secretariat for technical review according to Decision 13/CP.19. Ministry of Environment and Energy, Costa Rica. 2016. https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf

AD for land use change was estimated from the land use maps created for 1998-2011 and extracting multi-temporal values of the areas whose category remained unchanged and the areas that were converted to other land use categories.

To obtain annual AD, the land use change matrices were interpolated as follows:

- For all cells of the land use change matrices (except for the cells in the top/left – bottom/right diagonal):

$$AD_t = AD_p/T$$

Where:

AD_t	Interpolated annual AD applicable to year *t* within the monitoring period *p*; ha yr^{-1}
AD_p	AD for the period *p*; ha in *p* years
T	Number of years elapsed in the period *p* (e.g. 6 years for period 1986-91); years

- For all cells in the top/left – bottom/right diagonal of the land use change matrices:

$$AD_t = A_{(t-1)} - \Sigma(ADleft_t) - \Sigma(ADright_t)$$

Where:

AD_t	Interpolated annual AD applicable to year *t* within the period *p*; ha yr^{-1}
$A_{(t-1)}$	Area of the initial land use category at the end of the previous year (*t-1*); ha
$\Sigma(ADleft_t)$	Sum of all annual AD of year *t* in the cells of the same line of the matrix at the left of the cell for which AD is calculated; ha
$\Sigma(ADright_t)$	Sum of all annual AD of year *t* in the cells of the same line of the matrix at the right of the cell for which AD is calculated; ha

The average annual historical emissions over the reference period of activities in forest land remaining forest land (forest degradation and enhancements), a multi-temporal visual assessment of high resolution imagery Collect Earth software[120] detected forest canopy cover change in forest areas in 1998 and 2011, which were then extrapolated to the entire country through the application of the Olofsson et al (2014) methodology[121] for a proportional representation within the respective degradation classes (intact, degraded, and very degraded) and forestry type (Wet and Rain Forests, Humid Forests, Dry Forests, Mangrove Forests, and Palm Forests). Degradation classes were determined based on the reduction of the forest canopy cover, i.e. intact forests have a cover of 85-100%, degraded forests have a cover of 60-85%, and very degraded forests a cover of 30-59%. Forest areas that went from intact to degraded, intact to very degraded, or degraded to very degraded (in terms of their canopy cover) during the reference period (1998-2011) were classified as degraded, whereas forest areas that went from very degraded to degraded, very degraded to intact, or degraded to intact were identified as forest enhancement areas. These images were aligned to the dates of the land use change maps so that all activities could maintain the same reference period (1998-2011). The AD available in Costa Rica is spatially explicit, yet the program does not assign REDD+ activities to different zones of the country, because there was no projection of the location where future land cover change might occur, thus it can only be used as an estimate of total net emissions and removals.

The details on how all activity data were calculated REDD+ activity are provided in the parameter tables in Section 3 of this monitoring report.

Emission and removal factors:

The 2015 National Forest Inventory (NFI) was used to develop deforestation emission factors (EF) for primary forests, even though the NFI sampling was concentrated in accessible forest areas and thus the NFI plots most likely represent forests that have been disturbed or degraded. Aboveground biomass data for all forest strata from the

[120] For the multi-temporal visual assessment, the REDD Secretariat used the repository of images available in the Google Earth app, a dataset of 1998 orthophotos, and orthophoto mosaics available for the years 2005-2007. The Orthophoto mosaic 2005-2007 is accessible through the OGC services of SNIT (Sistema Nacional de Información Territorial) with the following WMS: https://geos0.snitcr.go.cr/cgi-bin/web?map=ortofoto.map&SERVICE=WMS&version=1.1.1&request=GetCapabilities
This orthophoto mosaic can also be accessed with the SNIT visor https://www.snitcr.go.cr/Visor/index (enabling layers Mosaico 1000 and Mosaico 5000.

[121] Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148, 42-57.

NFI campaign was then used to estimate the belowground, litter, and deadwood carbon pools. Scientific literature published since 2005[122] was used for soil carbon stocks and for aboveground growth rates in secondary forests. Forest remaining forests used the average ratio between aboveground biomass and canopy cover estimated for each forest type. This approach to estimate emission and removal factors from forests remaining forests is an update from the originally proposed linear model of canopy vs aboveground biomass approach. The new approach provides more robust estimates with lower uncertainties (see Section 1 of Annex 4, "Technical corrections" above for more details). The total carbon stock of each land use and forest category was estimated as the sum of all carbon pools.

To estimate average carbon stocks by carbon pool and land use category biomass data was converted to carbon using the carbon fraction of 0.47[123]. Carbon stocks were then converted to mean tons of CO_2e values with their associated uncertainties. Emission factors were estimated from carbon stock changes following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and available literature (e.g., Cairn's equation was used to determine belowground biomass from aboveground biomass[124]). To avoid double-counting of reference level emissions between deforestation and forest degradation, the analysis of degradation was only performed on the area of forest remaining forest according to the land use change (AGRESTA) maps. This avoided any measurements of degradation that was also accounted for under deforestation.

The details on how these emission and removal factors were calculated for each carbon pool and REDD+ activity are provided in the parameter tables in Section 3 of this monitoring report. In-depth details of methodological changes to the reference level in forests remaining forests are provided in the beginning of Annex 4, under Section 1 "Technical corrections".

Development of average annual historical emissions over the Reference Period:
The average of the historical period (1998-2011) is the most robust of the possible reference periods for the following reasons: First, this period starts shortly after Costa Rica's Forest Law banning deforestation activities passed in 1996. Therefore, 1998 is the earliest year after the Forest Law for which Costa Rica has a land use country map. Second, selecting 1998 as the base year of the reference period allows for the consideration of emission reductions that have resulted from the implementation of the current Forest Law.

The Reference Level was defined as the net annual average historical emissions. Annual emissions or absorptions were estimated for all land transitions i by REDD+ activity, and then adding the results for all selected REDD+ activities for each year:

$$RL_{RP} = \frac{\sum_{t=1}^{RP} ER_{RA_t}}{RP} = \frac{\sum_{t=1}^{RP} \sum_{i=1}^{I} \left(AD_{RA_{i,t}} * EF_{RA_{i,t}} \right)}{RP}$$

Equation 4

Where:

ER_{RA_t}	=	Emissions or removals associated to REDD+ activity *RA* in year *t*; tCO_2-e yr^{-1}
$AD_{RA_{i,t}}$	=	AD associated to REDD+ activity *RA* for the land use transition *i* in year *t*; ha yr^{-1}
$EF_{RA_{i,t}}$	=	EF associated to REDD+ activity *RA* applicable to the land use transition *i* in year *t*; tCO_2-e ha^{-1}
RP	=	Reference Period in years
i	=	A land use transition represented in a cell of the land use change matrix; dimensionless
I	=	Total number of land use transitions related to REDD+ activity *RA*; dimensionless
t	=	A year of the historical period analyzed; dimensionless

[122] Emission Reductions Program, FCPF Carbon Fund. Ministry of Environment and Energy (MINAE), Costa Rica. 2018. https://www.forestcarbonpartnership.org/system/files/documents/Costa%20Rica%20ERPD%20EN_Oct24-2018_clean.pdf
[123] Cairns M.A., Brown S., Helmer E.H., and Baumgardner G.A. (1997). Root biomass allocation in the world's upland forests. Oecologia 111: pp. 1-11.
[124]IPCC. IPCC guidelines for national greenhouse gas inventories. In: Eggleston S, Buendia L, Miwa K, Ngara T, Tanabe K, editors. Guidelines for national greenhouse gas inventories, vol. 4: Agriculture, Forestry, and Other Land Use. 2006.

Deforestation and Reforestation Activity Data (**AD_D** and **AD_R**) are calculated differently from Degradation and Enhancement Activity Data (**AD_{Deg}** and **AD_E**). Deforestation and Reforestation ADs result from the cartographic comparison of land-use maps from the beginning and end of the monitoring period. The Degradation and Enhancement DAs result from the sample-based estimation of canopy change area in permanent forest lands. Below are the equations used to calculate these parameters:

Activity Data of Deforestation (AD_D)	$AD_{D_{i,t}} = \left\|D_{i,t}\right\| * 0.81$, **Equation 2.1**	Where $\left\|D_{i,t}\right\|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Activity Data of Reforestation (AD_R)	$AD_{R_{i,t}} = \left\|R_{i,t}\right\| * 0.81$, **Equation 2.2**	Where $\left\|R_{i,t}\right\|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Forest remaining forests ($AD_{F\text{-}F}$)	$AD_{F-F_{i,t}} = \left\|F - F_{i,t}\right\| * 0.81$, **Equation 2.3**	Where $\left\|F - F_{i,t}\right\|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Activity Data of Degradation (AD_{Deg})	$AD_{Deg_k} = \frac{\left\|Deg_k\right\|}{N} * AD_{F-F_t}$ **Equation 2.4**	Where $\left\|Deg_{i,t}\right\|$ is the count of sampling points where canopy change decrease (dimensionless) in forest type k, *N* is the total of sampling points (dimensionless), and AD_{F-F_t} is the total area of permanent forest (in hectares – ha) in the monitoring period.
Activity Data of Permanent Forest Regeneration (AD_E)	$AD_{E_k} = \frac{\left\|E_k\right\|}{N} * \sum_{i=1}^{I} AD_{F-F_{i,t}}$ **Equation 2.5**	Where $\left\|E_{k,}\right\|$ is the count of sampling points where canopy change increase (dimensionless) in forest type k, *N* is the total of sampling points (dimensionless), and AD_{F-F_t} is the total area of permanent forest (in hectares – ha) in the monitoring period.
Emissions & Removals from Deforestation $E_{D\&R(AAAA-AA)}$	$E_{D\&R(AAAA-AA)} = \sum_{k=1}^{I} AD_{D_{i,t}} * EF_{D_i} + \sum_{k=1}^{I} AD_{R_{i,t}} * EF_{R_i}$ **Equation 2.6**	Where ***i*** is a land-use transition represented in a cell of the land-use change matrix (dimensionless), EF_{D_i} is the deforestation emission factor for land-use transition ***i***, EF_{R_i} is the removal factor for land-use transition ***i*** (when land-use transition ***i*** is forest loss, activity data and emission factor for forest recovery are cero and vice versa).
Emission & Removals from Degradation $E_{Deg(AAAA-AA)}$	$E_{Deg(AAAA-AA)} = \sum_{i=1}^{I} AD_{Deg_k} * EF_{Deg_k} + \sum_{i=1}^{I} AD_{E_k} * EF_{E_k}$ **Equation 2.7**	Where k is a forest type, EF_{Deg_k} is the degradation emission factor for forest type k, EF_{E_k} is the removal factor for forest type k.

EFs were determined from C stocks. C stock changes (ΔC) were estimated using the Stock-Difference Method by applying IPCC (2006) equation 2.5 (cf. Volume 2, Chapter 2, Section 2.2.1.). All results were multiplied by the stoichiometric ratio 44/12, as follows:

$$\Delta C = \frac{(C_{t2} - C_{t1})}{(t2 - t1)} * 44/12 \quad \textbf{Equation 5}$$

Where:

ΔC	=	C stock changes associated to the land use transition *i* in year *t*; tCO_2-e ha^{-1}
C_{t1}	=	C stock at time *t1*, t CO_2 ha^{-1} *t1* in all cases was the 1st of January of each year *t*, *i.e.* C_{t1} is the C stock per hectare existing at the beginning of the year, before the conversion occurs. The estimated values are reported in the column K of the sheets "ER AAAA" (where "AAAA" stands for the year *t*) in the FREL TOOL.
C_{t2}	=	C stock at time *t2*, t CO_2 ha^{-1} *t2* in all cases was the 31st of December of each year ***t***, *i.e.* C_{t2} is the C stock per hectare existing

at the end of the year, after the conversion occurred. The estimated values are reported in the lines 19[125] and 20[126] of the sheets "ER AAAA" (where "AAAA" stands for the year *t*) in the FREL TOOL.

t2-t1 = In all cases the C stock changes were estimated annually, *i.e. t2-t1* = 1 year.

44/12 = Conversion of C to CO_2

Forest C is determined from the NFI biomass data, converted to carbon as follows:

$$C_t = \sum_{j,i} (B_{tot}) \text{ x CF}$$ **Equation 6**

Where:

B_{tot} = Total biomass stock for the land use category *LU*; tCO_2-e ha^{-1}.
Total biomass is equivalent to the sum of all biomass pools: $B_{tot} = B_{AGB} + B_{BGB} + B_{DW} + B_L$
Where:
AGB is above-ground biomass for land use category *LU*; tCO_2-e ha^{-1}
BGB is below-ground biomass for land use category *LU*; tCO_2-e ha^{-1}
DW is dead wood biomass for land use category *LU*; tCO_2-e ha^{-1}
L is litter biomass for land use category *LU*; tCO_2-e ha^{-1}

CF = Carbon fraction of dry matter in tC per ton dry matter. The value used is:
0.47 is the default for (sub)tropical forest as per IPCC AFOLU guidelines 2006, Table 4.3.

Carbon stocks of non-Forest land uses are estimated as the average values reported by the selected studies:

- *Cropland:* carbon stock values reported in selected studies showed high variability, depending on crop type (sugar cane, coffee, banana, cocoa, etc.). For this reason, the carbon stock data compiled were weighted by the surface area of the respective crops in Costa Rica to produce a single estimate of carbon stocks from cropland.
- *Grassland:* carbon stocks were estimated as the average values reported in different carbon pools in the selected studies.
- *Settlements and (non-forested) Wetlands:* no studies could be found reporting biomass values for these categories. It was assumed that their carbon stock is zero.
- *Other Land:* studies were found reporting carbon stocks for *Paramo.* In the case of *Bare Soil* it was assumed carbon stocks are zero.

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

Activity data

Table 19: Source of Activity Data and description of the methods for developing the data for estimate emissions from deforestation during the reference period[127].

Parameters:	**Activity Data of Deforestation (AD_D) Eq. 2.1** **Activity Data of Reforestation (AD_R) Eq. 2.2** **Forest remaining forests (AD_{F-F}) Eq. 2.3**
Description:	Deforestation: Hectares of forest that changed to non-forest land in a year summed each year (i) of the reference period.

[125] The C stock values reported in line 19 represent total C stocks existing in secondary forest and tree plantation at the end of the first year at which they meet the definition of "Forest", i.e., 4 years for all forest strata and 8 years for dry forests. These values are used to estimate ΔC in conversions of non-Forest land use categories to Forest land and conversions of other land use categories to permanent crops.

[126] The C stock values reported in line 20 represent total C stocks existing in the land use categories at the end of the year. They are used to estimate ΔC in all land use transitions, except conversions of non-Forest land use categories to Forest land and conversion of other land use categories to permanent crops.

[127] All AD parameters listed in table 13 sourced from the same survey.

	Reforestation: Hectares of non-forest that changed to forest land in a year, summed for each year (i) of the reference period. Forest remaining forests: Hectares of Forest remaining forests in a year, summed for each year (i) of the reference period
Data unit:	Hectares
Source of data	
Introduction	AD for land-use change activities was derived from map-algebra by analyzing all land cover maps created for 1998-2011 and estimating multi-temporal data for the areas that remained in the same category or converted to other land cover categories. Annual AD was interpolated for years in which maps were not produced. A time-series of land use maps was created for 1985/86-2012/13 in a Geographical Information System (GIS)[128] and then extracting the values of the areas that remained in the same category or converted to other land use categories from the combined set of multi-temporal data. The area covered by the land-use maps includes the country's continental territory (5,133,939.50 ha) but excludes Coco Island (238,500 ha). The land use maps were created using the methodology summarized here; further information may be found in separate reports [129,130,131] :
Data sources for estimating activity data:	The construction of the AD time series required the following sources of data: v. Remotely sensed data from four generations of the Landsat family (Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM and Landsat 8 OLI/TIRS). vi. A "Life Zones" map according to the classification system of Holdridge (1966). This map was used to stratify "Forests" into the three sub-categories: "Wet and Rain Forests", "Moist Forests" and "Dry Forests". vii. Ancillary data to edit the results of the spectral classification of remotely sensed data and to further stratify the five forest categories "Wet and Rain Forests", "Moist Forests", "Dry Forests", "Mangroves" and "Palm Forests" into the sub-categories "primary forests" and "secondary forest. viii. The Global Forest Change project (Hansen et al., 2013) has been used to fill in pixels without information in the mosaic of classifications for each year of the series between 2000 and 2012.
Methods for mapping land-use and land-use change	
Selection of images	Costa Rica prepared the FREL / FRL Costa Rica from a time series of satellite images for 1987-2013. The time series includes images from four generations of LANDSAT satellites: Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM +, Landsat 8 OLI / TIRS. The analyst downloaded the satellite information through the USGS Earth Explorer server. It was necessary to work with seven LANDSAT scenes to cover the continental territory of Costa Rica in each of the years of the series: two scenes from path 14 (rows 53 and 54), three scenes from path 15 (rows 52, 53, and 54) and two scenes from path 16 (rows 52 and 53). Low cloud-coverage Landsat images were combined to minimize the area covered by clouds and cloud shadows. In most cases, the scenes were selected from the same year and season but, in some cases, it was necessary to choose scenes from different years within a 14-month timeframe.
Pre-processing and Geometric validation	All images were registered to a standard system of coordinates (CRTM05). The mean quadratic error in control points was less than one pixel (30 m). The maximum registration error was estimated at 2 pixels (60 m). The 2005 orthophotography generated with the IDB-Cadastral project's CARTA mission has been used to collect control points for the geometric validation of the reference runs. A mosaic of scenes is prepared for each path's available dates with the geometrically corrected images.

[128] The geodatabase with the time-series of land use maps created for the reference period 1985/86-2012/13 can be accessed at the following link: https://drive.google.com/drive/folders/1XulVBwfZNam6acIksq-ZMQoK_ISqy0V2?usp=sharing

[129] Agresta, Dimap, Universidad de Costa Rica, Universidad Politécnica de Madrid. 2015. Final Report: Generating a consistent historical time series of activity data from land use change for the development of Costa Rica's REDD plus reference level: Methodological Protocol. Report prepared for the Government of Costa Rica under the Carbon Fund of the Forest Carbon Partnership (FCPF). 44 pp. https://www.dropbox.com/s/ygjw6zq00a1qtbm/Informe_tecnico_feb_2015.pdf?dl=0

[130] Ministry of the Environment and Natural Resources of Costa Rica. (2016). Modified REDD+ Forest reference emission level/forest reference level (FREL/FRL). COSTA RICA. SUBMISSION TO THE UNFCCC SECRETARIAT FOR TECHNICAL REVIEW ACCORDING TO DECISION 13/CP.19. Retrieved from https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf

[131] Ministry of the Environment and Natural Resources of Costa Rica. (2018). Costa Rica Emission Reductions Program to the FCPF Carbon Fund (Second Revision). Retrieved from https://www.forestcarbonpartnership.org/system/files/documents/Costa Rica ERPD EN_Oct24-2018_clean.pdf

Radiometric normalization	All images were radiometrically normalized. This process is applied to reduce radiometric differences between images due to atmospheric conditions and the sensors' calibration at image acquisition dates. The radiometric normalization was done using the "Iteratively Reweighted Multivariate Alteration Detection" (IR-MAD), as described by Canty and Nielsen (2008)[132]. The normalization of the time series used as a reference the zenith angle 36.90° corresponding to February 17, 2013.
Random Forest classification	The classification of the images uses the Random Forest (RF) method. This methodology has 2 phases: (1) training or adjustment of the RF and (2) classification of the images using the generated RF classifier. Homogeneous regions of interest have been digitized according to the land cover classes between 2011 and 2014 (see Table 3 of Agresta, 2015) for the models' adjustment. The base information used for the digitization and photointerpretation of these regions has been i) the systematic grid of cover points taken on the RapidEye images by SINAC for the elaboration of the map of forest types of Costa Rica 2013 (10,000 points distributed in the national territory), ii) the RapidEye high spatial resolution images themselves, iii) both current and historical images available on Google Earth. Control points for RF training have been randomly generated from these regions of interest. In total, 20 predictor variables (also called covariates or auxiliary variables) were used for the adjustment of the RF models, divided into four groups: (1) Spectral information of the bands, (2) Indices of vegetation, (3) Variables related to the texture of the image, and (4) Variables derived from the Digital Elevation Model. The analyst applied the classifiers to all the images according to their path and sensor. The result is a classification file for each classified image.
Postprocessing	Final maps are presented at 30 meters resolution. The preparation of the final maps from the classified images included the following tasks: vi. Union of the mosaic for each date from the classified images using a pixel prioritization algorithm. The analyst merged all the different images' classifications for each of the dates and paths, eliminating the extreme strip of the paths overlapping. If the classifier predicts several classes for the same pixel, the most common category was selected, according to band 2 of the results. vii. Filling gaps with global products: The Global Forest Change project (Hansen et al., 2013) has been used to fill in pixels without information in the mosaic of classifications for each year of the series between 2000 and 2012. viii. Multi-temporal analysis: the multi-temporal analysis of the series allowed assigning the age class to each of the forest pixels, analyzing the years that have elapsed from the date of appearance of a new forest. The forest from 1987 has been considered a primary forest. Also, the multi-temporal analysis improved land-uses classification, especially when the land cover has similar spectral information. The classifier confused native forests with forest plantations. For this reason, the forest plantations were reclassified as forest. ix. Minimum mapping unit: The analyst replaced Forest Class groups of pixels smaller than 11 pixels with the LULC class of the largest neighboring group to comply with the minimum area threshold of the definition of "forest (1.00 ha), and setting the minimum mapping unit. Due to the pixels' dimensions in the Landsat images (30.00 m x 30.00 m), the minimum mapping area is 0.99 ha, equivalent to 11 pixels (11 x 30.00 m x 30.00 m). x. Manual editions: In order to improve land use mapping, several editions were made, largely aimed at decreasing high classification errors (for more detail please see section 4.3.3 in Ministry of the Environment and Natural Resources of Costa Rica, 2016[133]): a. "Forest Plantations" were merged with the "Forest land" category. This means that although initially classified as a separate class, @Forest Plantations@ presented a very high classification error and, for purpose of GHG estimation, it was treated as Forest land". b. For estimating the area of "Coffee Plantations", the analyst used ancillary maps from the Ministry of Agriculture (MAG), the Costa Rican Coffee Institute (ICAFE), and the Costa Rican Meteorological Institute (IMN). These maps were used to correct the classified areas for the years 2000/01, 2007/08, 2011/12, and 2013/14. For previous maps, a mask

[132] Canty, M. J. y A. A. Nielsen, 2008. Automatic radiometric normalization of multitemporal satellite imagery with the iteratively re-weighted MAD transformation. Remote Sensing of Environment 112 (2008):1025-1036.

[133] Ministry of the Environment and Natural Resources of Costa Rica. (2016). Modified REDD+ Forest reference emission level/forest reference level (FREL/FRL). COSTA RICA. SUBMISSION TO THE UNFCCC SECRETARIAT FOR TECHNICAL REVIEW ACCORDING TO DECISION 13/CP.19. Retrieved from https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf

	representing potential "Coffee Plantation" areas was created using the location and elevation of all areas mapped as "Coffee Plantations" considering all available sources of information (MAG, ICAFE, and IMN). c. Paramo, Mangroves and Palm forests are ecosystems restricted to particular elevation, edaphic, inundation, and salinity conditions; it is challenging for such ecosystems to exist in other locations. Therefore, these forests were re-classified using the map of Forest types (MTB), prepared by Agresta (2015). All masks representing "Mangroves", "Palm Forests" and "Paramo" have been compiled in a map of masks that will be kept in order to enable consistent map editions in future measurement and reporting. d. Areas classified as "Urban Areas" in 2013/14 were manually edited through visual interpretation of 2013 high resolution RapidEye images and creation of a mask representing "Urban Areas" in 2013/14. Pixels originally classified as "Urban Areas" outside the mask were reclassified as "Bare Soil" and conversely, pixels classified as "Bare Soil" inside this mask were reclassified as "Urban Areas". Additionally, under the assumption that "Urban Areas" never convert to other land use categories, all pixels e. A map of potential forest types was created to assign secondary forests to a forest type (Wet and Rain Forests, Moist Forests, Dry Forests, Mangroves, Palm Forests). This map will also be used in future measurements for determining the forest type of secondary forests. The map of potential forest types was created by combining the life-zones and then overlapping the map of the masks of potential areas of "Mangroves", "Palm Forests", and "Paramo".
Activity Data calculation	AD for land use change activities such as *deforestation* and *reforestation* were estimated by combining all land use maps created for 1998-2011 in a Geographical Information System (GIS) and then extracting from the combined set of multi-temporal data the values of the areas that remained in the same category or converted to other land use categories. The results of this operation are reported in land use change matrices prepared for each measurement period in the sheets "LCM 1986-91", "LCM 1992-97", "LCM 1998-00", "LCM 2001-07", "LCM 2008-11", and "LCM 2012-13" of the spreadsheets tool "FREL TOOL CR[134]".
Value applied in reference period:	
	1998-2011: • Total anthropogenic deforestation: 30,439 ha yr^{-1} • Primary forest anthropogenic deforestation: 13,147 ha yr^{-1} • Secondary forest and tree plantation anthropogenic deforestation: 17,292 ha yr^{-1}
QA/QC procedures applied	
Introduction	The QA/QC procedures applied during the preparation of the land-use maps used to calculate AD for the reference period are summarized here, further information may be found in Agresta (2005), Sections 3, 4, and 7:
Download and satellite image preparation	9. Verification of file storage errors in digital media that could affect reading the data by the analyst responsible for download support images. 10. Previewing and verification of the satellite image quality and metadata by the analyst responsible for downloading support images. 11. Previewing and verification of the satellite image quality and metadata by the supervisor.
Image orthorectification	17. Analyst's exhaustive visual inspection to identify errors in the orthorectification process, such as duplicated areas, pixel stretching, or geometric errors related to the digital terrain model (DTM). 18. Geometric control of orthorectified images by taking checkpoints in each scene in a regularly distributed grid. 19. Validation of root mean square error (RMSE) of the control points, by the analyst responsible for the orthorectification. In no case, RMSE is above the pixel size of the image. The number of correct points after debugging should not be less than 20 ground control points in each reference path. The RMSE obtained in the checkpoints is less than 1 pixel (30 meters), and the maximum error in any of the points, 2 pixels (60 meters).

[134] The FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing

	20. Preparation of a "georeferencing validation datasheet," including a general image view with the checkpoints marked on it and a list of the coordinates and RMS obtained for each point. Annex 5 of Agresta (2015) includes the lists of checkpoints and RMSE of the dates processed.
Radiometric normalization:	21. Radiometric normalization to reduce the differences between the time-series images.
Generation of cloud and shadow masks	22. Validation of cloud and shadow mask by visual verification of a systematic random grid of checkpoints identified as a cloud (n), shadow (s), or clear (d). The analyst visually checked the original image in RGB or false color if the classification matches the cloud and shadow mask. The analyst must pay special attention to the verification of cloud masks in urban areas and coastlines with a high reflectance, adjusting some of the cloud and shadow mask degeneration parameters during the verification process. 23. The validation includes a random sample in each path of an image from each time series (3 paths x 6 series = 18 images). Table 2 of Agresta (2015) includes a summary of the results of the validation of the cloud and shadow maps.
Land use classification:	24. Analysts perform an iterative process of classification, verification of results, error detection, and review of areas and training points. 25. Progressive improvement of the areas and training points of the RF classifier before the final classification of the images. Review of the Random Forest classifiers' errors, identify classes that need improvement, and training points. 26. Visual verification and validation of classified images by comparing them with the available high-resolution image.
Preparation of land-use maps:	27. Visual check of mosaics and identify information gaps and sensor failures on each time series' images. 28. Visual verification of the maps generated after filling the gaps with global data. 29. Analysts implement an independent validation of the land-use change maps with ground validation points provided by the country's institutions not used in the classification phase. 30. Manual edition of the time-series classification to improve land use mapping, largely aimed at decreasing high classification errors.
Visual verification and validation of land-use change map:	31. Visual verification of the country's main deforestation and reforestation areas between consecutive years of the series to detect classification errors. 32. Validation of land-use changes between 2001 and 2011 based on photointerpretation of changes on a systematic random grid of points and using the Landsat, aerial orthophotography of the year 2005, and Rapid-eye images of the years 2011 and 2012.
Uncertainty associated with this parameter:	
Uncertainty associated with this parameter:	Uncertainties associated to AD are due to the production process of land use maps. The uncertainties of the AD for land use change activities (deforestation and reforestation) and forest remaining forest activities (degradation and enhancements in forest lands) come from the uncertainties (i.e. the margin of error for a 90% confidence level divided by the estimate) associated with the process creating land use change maps from which the activity data are obtained. The accuracy assessment of the land-use change map 2001/02 – 2011/12 was done following Olofsson et al.'s (2014)[135] guidelines. Due to a large number of land-use change transitions, they were aggregated into four categories: Deforestation (forest to non-forest), new forests (non-forest to forest), stable forest (forest remaining forest), and stable non-forest (non-forest to non-forest). The validation of land-use changes during the period 2000/2001 - 2010/2011 is based on the photointerpretation of orthophotography from 2005, Rapid eye imagery, and Landsat images, since they have higher quality and spatial resolution than the maps and are independent of the sample of land-use data used to produce the maps. For further detail please see section 12.2 in ERPD document (Ministry of the Environment and Natural Resources of Costa Rica, 2018)[136]. Finally, 699 checkpoints were assessed: 315 in stable forest areas (areas classified as forest in 2000/01 remaining forest in 2010/11), 237 in the non-stable forest (areas classified as non-forest in 2000/01 remaining non-forest in 2010/11), 53 in afforestation/reforestation areas (areas classified as non-forest in 2000/01 classified as forest in

[135] Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148, 42-57.
[136] Ministry of the Environment and Natural Resources of Costa Rica. (2018). Costa Rica Emission Reductions Program to the FCPF Carbon Fund (Second Revision). Retrieved from https://www.forestcarbonpartnership.org/system/files/documents/Costa Rica ERPD EN_Oct24-2018_clean.pdf

	2010/11) and 47 in deforested areas (areas classified as forest in 2000/01 classified as non-forest in 2010/11)[137]. The accuracy assessment analysis is presented in the Excel file "CDI_CostaRicaREL_AnalisisExactitud_MCS2000-2001 vs MCS2010-2011" [138]. The activity data's uncertainty is the bias between the adjusted (reference data) and estimated (land use maps) areas. The uncertainty values are as follows (see cells F56-F59 of spreadsheet "2.4E Datos Actividad 2001-2011 in excel file CDI_CostaRicaREL_AnalisisExactitud_MCS2000-2001 vs MCS2010-2011: Uncertainty of hectares of deforestation from 1998-2011: 26% Uncertainty of hectares of non-forest that changed to forest land: 51% Uncertainty of hectares of forests remaining forests in 1998-2011: 4%

[137] Shape file with 716 checkpoints included in the accuracy assessment analysis can be accessed in the following link: https://drive.google.com/drive/folders/1ofSZs-IfdZ-BzFxefqrGO1pwbp537HL1?usp=sharing

[138] Accuracy Assessment 2001-2011 analysis can be accessed in the following link (CDI_CostaRicaREL_AnalisisExactitud_MCS2000-2001 vs MCS2010-2011.xlsm excel file): https://drive.google.com/file/d/1wUfwkW4E74Y-AZHCesr4coNIs0e_SabC/view?usp=sharing

Table 20: Source of Activity Data and description of the methods for developing the data for estimate emission from degradation during the reference period.

Parameters:	**Activity Data of Degradation (AD_{Deg}) Eq. 2.4** **Activity Data of Permanent Forest Regeneration (AD_E) Eq. 2.5**
Description:	Degradation: Hectares of forest with a reduction of canopy cover during the reference period. Forest Enhancement: Hectares of forest with an increase of canopy cover during the reference period
Data unit:	Hectares
Source of data	
Introduction	The forest degradation assessment was made on forest lands that remain as forest lands. The analysis of degradation was only performed on the area of forest remaining forest according to the land-use MCS 2012/13 map to avoid double-counting of baseline emissions between deforestation and forest degradation. This procedure avoided any measurements of degradation that were also accounted for under deforestation. Reference data to estimate Degradation AD were collected by Ortiz-Malavassi, (2017)[139].
Type of sampling	A Systematic Sampling (SYS) over the Level 1 Systematic Grid of 10,242 points of the Monitoring system of land-use change and ecosystems (SIMOCUTE) was used. The original systematic grid is in the CRTM05 coordinate system of Costa Rica. However, it was re-projected to geographic coordinates in WGS84 to evaluate the sampling point with the Collect Earth Desktop tool. The SIMOCUTE sampling units are permanent, which facilitates reinterpretation through time and easy temporal tracking of LULC changes.
Sampling Unit	The Sampling Unit (SU) is a 90x90 meter plot whose central point coincides with the SIMOCUTE sampling points. The SU corresponds to 3x3 Landsat pixels and covers 0.98 ha. Inside SU, a 7x7 points sub-grid was created to estimate land cover percentage within each sampling unit.
Number of Sampling Units	The forest degradation assessment was made on forest lands that remain as forest lands during 1998-2016. A total of 4377 points were classified as permanent forest land according to the MCS 2012/13 map. These points are an extract from the Systematic Grid adopted in SIMOCUTE.
Classification scheme	Three classes of canopy cover were considered to estimate degradation/enhancement in permanent forest land: i. Intact forest (85-100% forest cover), ii. Degraded forest (60-85% forest cover), and iii. Very degraded forest (<60% forest cover). The following forest cover change classes were assessed by forest type and type of carbon fluxes (anthropogenic and natural): Degradation: j. Intact to Degraded forest k. Intact to Very degraded forest l. Degraded to Very degraded forest Forest enhancement: m. Very degraded to intact forest n. Very degraded to degraded forest o. Degraded to Intact forest No Condition changes p. Stable intact forest q. Stable degraded forest r. Stable very degraded forest
Imagery Sources	The range of dates of the images presented in the table below was used. Priority was given to operating with the ortho-rectified photographs of the TERRA 1997 project to evaluate the canopy cover in 1998. Still, since TERRA 1997 covered less than 40% of the national territory, the second priority was to use high-resolution images in Google Earth before 2006. If these did not exist, the next priority was to use the ortho-rectified photos of the project Carta-2005 available on the SNIT server. For the other years, the repository of high-resolution images

[139] Ortiz-Malavassi, E. (2017). Evaluación Visual Multitemporal (EVM) del Uso de la tierra, Cambio en el Uso de la Tierra y Cobertura en Costa Rica Zonas A y B Tarea 1: Estimación del área de cambio de uso de la tierra durante el periodo 2014-2015. Retrieved from https://drive.google.com/file/d/1GXdN43f-DNKelkM8y7gBLrKou-f7LI-G/view?usp=sharing

available in Google Earth and Earth Engine was used as a data source, giving priority to images from the years to be evaluated (2011 or 2016). However, in case of absence, the use was recorded in the year closest to monitoring dates. Data sources and imagery date range used in the canopy cover evaluation on permanent forest for the reference period 1998-2011 are the following:

Monitoring Year	Imagery date range	Data sources
1998	January 1997 – December 2005	• Orthophotos TERRA 1997. • Google Earth imagery repository • Mission CARTA 2005
2011	July 2011 – June 2012	• Google Earth imagery repository
2016	July 2015 – June 2016	• Google Earth imagery repository

Interpretation Key

The land cover class keys used to determine canopy cover for the years 1998, 2011, and 2016 are the following:

Code	Land cover class
1100	Trees
1200	Shrubs
1300	Herbaceous
1400	Palm
1500	Bromeliads
1600	Greenhouse
1700	Other vegetation
2000	No vegetation
3000	Water
4000	Clouds and shadows
5000	Not classifiable

Data collection

See QA/QC procedures.

Data analysis

The country developed a tool for calculating emissions and removals on permanent forest lands (¨Herramienta_degradación.xlsx¨ [140]). The database for the visual interpretation of canopy cover for the reference period 1998-2011 and period 2012-2016 are included in the sheet "Base_de_datos”. The area of degraded and enhanced forest areas was extrapolated to the forest area in the entire country through proportional representation within the respective degradation classes (intact, degraded and very degraded) and forestry type. Degradation classes were determined based on the reduction of the forest canopy cover, by which intact forests have a cover of 85-100%, degraded forests have a cover of 60-85%, and very degraded forests a cover between 30% and 59%. Forest areas that went from intact to degraded, intact to very degraded, or degraded to very degraded (in terms of their canopy cover) during the assessment period (1998-2011) were classified as degraded. Forest areas that went from very degraded to degraded, very degraded to intact, or degraded to intact were identified as forest enhancement areas. Carbon fluxes were estimated for anthropogenic and natural conditions. Fluxes from sampling points inside protected areas and farther than 500 meters from a road[141] were considered natural fluxes and removed from reference level accounting. The estimation

[140] Degradation tool can be accessed in the following link: https://drive.google.com/file/d/1GG3Z_QMWBKGNRdXnF_TdWP1ipH9dX5iH/view?usp=sharing

[141] The latest and highest-resolution official roads map for Costa Rica was used for this exercise, which was completed in 2007. It is accessible via the National System of Territorial Information (SNIT) website: http://www.snitcr.go.cr/Metadatos/full_metadata?k=Y2FwYW1ldGFkYXRvczo6Y2FwYTo6SUdOXzU6OnZpYXNfNTAwMA

	of the areas of change of degradation and canopy enhancement, for both anthropic and natural carbon fluxes, can be found in the sheet ¨Resumen_de_puntos¨ of the Degradation tool, for the reference period 1998-2011 and period 2012-2016.
Value applied in reference period:	
	• **2,233,119** hectares of forests remaining forests in the reference period (1998-2011) • **145,556** hectares of anthropogenic degradation (1998-2011) • **157,739** hectares of anthropogenic forest enhancement (1998-2011)
QA/QC procedures applied	
	Ortiz-Malavassi (2017) prepared a land cover evaluation protocol to reduce the uncertainty of the land cover classification due to: a) the bias associated with the spatial registration of the reference image, b) the interpreter bias in the assignment of the land cover class; and c) interpreter variability. The protocol includes the operational definition of the canopy coverage with examples taken from high-resolution images and registration templates for Collect Earth Desktop. The following procedures were applied during the collection of reference data: **Data registry forms**: The canopy cover change information was recorded in standard Collect Earth Desktop forms. **Variability between interpreters**: The analysts recorded screenshots, plot numbers, and a brief description of the problem in case of doubts with the interpretation (land cover and land-use). Every two days, they sent the log to other analysts for feedback. This feedback was available to all team members. Meetings will be held at the end of the week to discuss complex cases to reduce interpreters' variability. **Validation of the coverage classification**: The supervisor validated land cover classification with National Forest Inventory land cover data. This information was available only for the supervisors. **Imagery co-registration:** Google Earth images can show displacements, which became evident when the interpreter compares the same area for different years. Potere (2008)[142] found that the average displacement in developing countries is 44.4 meters. When this problem occurred, the analyst noted the maximum displacement detected in meters in Collect Earth form. **Data consistency:** The supervisor reviewed the existence of discrepancies between cover class and land use.
Uncertainty associated with this parameter:	
	In the assessment of degradation level in forests remaining forests, it was assumed that there was no uncertainty associated with the visual interpretation of sample areas because this procedure employed visual classification of canopy cover using high resolution imagery, as described in Section 8.4. ERPD. Uncertainty of changes in canopy cover to identify areas of degradation and forest enhancement from 1998-2011 vary depending on the forest type and the conversion class. It is based on the sampling error.

Emission factors

Table 21: Source of Emission Factors and description of the methods for developing the emission factors for deforestation.

Parameters:	**Carbon density of aboveground tree or woody biomass (C_{AGB}) Eq. 4** **Carbon density of belowground biomass (C_{BGB}). Eq. 4.** **Carbon density of dead wood biomass (C_{DWB}). Eq. 4** **Carbon density of litter (C_L). Eq. 4**
Description:	• **C_{AGB}**: Amount of carbon (C) contained in aboveground biomass per forest hectare, converted to CO_2e multiplying by a factor of 44/12 (i.e., the molecular weight of a CO_2 molecule over the molecular weight of a C molecule).

[142] Potere, D. (2008). Horizontal positional accuracy of Google Earth`s high-resolution imagery archive. In: Sensors, 8,12: 7973-7981 p. Retrieved from: http://www.mdpi.com/1424-8220/8/12/7973/htm

	• **C_{BGB}**: Amount of C contained in belowground forest biomass per forest hectare, converted to CO_2e multiplying by a factor of 3.67 (i.e., the molecular weight of a CO_2 molecule over the molecular weight of a C molecule). • **C_{DWB}**: Amount of C contained in dead wood forest biomass (standing and lying) per forest hectare, converted to CO_2e multiplying by a factor of 3.67 (i.e., the molecular weight of a CO_2 molecule over the molecular weight of a C molecule). • **C_L**: Amount of CO_2e contained in litter forest biomass per forest hectare.
Data unit:	Tonnes of CO_{2e} per hectare
Source of Data	
Introduction	The emission factor for deforestation of primary forest is derived from data collected during Costa Rica's first National Forest Inventory (INF-CR for its acronym in Spanish), and models or average values of direct measurements reported in literature. • **Carbon pool of aboveground tree or woody biomass (C_{AGB}):** Carbon pool of aboveground tree or woody biomass for each Primary Forest type (C_{AGB}) is the area-weighted average of C_{AGB} stock value from 2015 field campaign performed for the National Forest Inventory. • **Carbon pool of belowground biomass (C_{BGB})**: Derived directly from C_{AGB} data following the Cairns et al., (1997) formula. • **Carbon pool of dead wood biomass (C_{DWB})**: Average values of direct measurements reported in literature. The value was used to develop a ratio of C_{DWB} over C_{AGB} used for AD_D, AD_{F-F}, and AD_R. The values obtained from the literature were used to develop an area-weighted average of DW:AGB ratios, assumed to be the same in primary and secondary forests. • **Carbon pool of litter (C_L):** Average values of direct measurements reported in literature. The value was used to develop a ratio of C_L over C_{AGB} used for AD_D, AD_{F-F}, and AD_R. The values obtained from the literature were used to develop an area-weighted average of L:AGB ratios, assumed to be the same in primary and secondary forests.
Source of Data of Above Ground Biomass for Primary Forest	**Type of sampling:** The INF-CR is a multipurpose inventory seeking to enhance the understating of Costa Rican forest resources and generate data to monitor and quantify their provision of ecosystem services, such as climate change mitigation. The INF-CR was led by the National Conservation Area System (SINAC) with measurements taken between 2013 and 2015. The INF-CR employed a stratified-systematic sampling approach covering the entirety of Costa Rica's continental territory. The stratification was based on a forest type map derived from RapidEye imagery (REDD/CCAD-GIZ-SINAC, 2015)[143] and plots were equidistantly allocated within each stratum. **Sampling Unit:** Rectangularly shaped plots with an area of 0.1 ha (20m x 50m) distributed on fixed sample intensities by forest class. The sampling unit design allows the measurements of the following (Ministerio de Ambiente y Energía, 2015)[144]: • Primary Sampling Unit (UMP for its acronym in Spanish) for measurement of live tree DBH and height of trees with DBH ≥ 10cm (light green area) • Secondary Sampling Unit (UMS for its acronym in Spanish) for measurement of saplings with 2cm ≤DBH<10cm, and height >1.5m. • Third-order Sampling Unit (UMT for its acronym in Spanish) for measurement of live non-tree vegetation, including seedlings (DBH<2cm and height<1.5m), were taken (light grey circles) • Fourth-order Sampling Unit (UMC for its acronym in Spanish) to measure the abundance of species. • Fifth-order Sampling Unit (UMH) to measure litter. • Lying deadwood sampling (UMM) to measure the lying deadwood's diameter in the 20m transects. Soil sampling of the first 30cm with cylinder method. **Number of Sampling Units:** The INF-CR installed a total of 286 single plots. Out of the 286 sampling units (SU), litter was sampled only in 54, and lying deadwood in 61 SUs. Because of inconsistent sampling of all carbon pools across all plots and lack of confidence in data where litter and

[143] Sistema Nacional de Áreas de Conservación (SINAC) - Programa REDD-CCAD-GIZ. (2015). Cartografía base para el Inventario Forestal Nacional de Costa Rica 2013-2014. Retrieved from https://www.sirefor.go.cr/pdfs/Documento-cartografia-Imprenta.pdf

[144] Ministerio de Ambiente y Energía. (2015). Volumen 4 Marco conceptual y metodológico para la Inventario forestal nacional de Costa Rica. Retrieved from https://www.sirefor.go.cr/pdfs/Volumen4-MarcoC-Imprenta.pdf

	deadwood, a decision to consider only aboveground biomass from INF-CR was made. Some SU presented zero as a result of litter and deadwood pools. It was not verified whether the SU represented the absence of litter and deadwood in the plots, or these carbon pools weren't sampled.
Source of Data of Above Ground Biomass for Secondary Forest	The AGB for secondary forest was estimated assuming the forest stand accumulated biomass since its restoration. The AGB of Wet and Rain Forests, Moist Forests and Dry Forests were estimated using the equations developed by Cifuentes (2008)[145] based on direct measurements in 54 plots located in age classes between 0 and 82 years. For Mangroves and Palm Forests, a linear function was assumed for estimating carbon stocks as a function of age. Wet and Rain Forests (Cifuentes, 2008, Table 2.5, p. 42, equation for "*Tropical Wet*"): $$TAGB_t = B_{max} * \left[1 - e^{(-0.0186*t)}\right]^1$$ Moist Forests (Cifuentes, 2008,, Table 2.5, p. 42, equation for "*Tropical Permontane Wet Transition to Basal-Atlantic*"): $$TAGB_t = B_{max} * \left[1 - e^{(-0.0348*t)}\right]^1$$ Dry Forests (Cifuentes, 2008,, Table 2.5, p. 42, equation for "*Tropical Dry*"): $$TAGB_t = B_{max} * \left[1 - e^{(-0.113*t)}\right]^{5.1411}$$ Mangroves and Palm Forest the following linear equation was applied: $TAGB_t = \frac{B_{max}}{100} * t$, when t <= 100 $TAGB_t = B_{max}$, when t > 100 It was assumed that the maximum biomass in secondary forests (B_{max}) equals the biomass estimated for primary forests.
Source of data of Litter and Deadwood in primary and secondary forest	The carbon stocks of litter and deadwood were estimated based on a compilation of values from published literature. All C stock estimates from the consulted sources were compiled in tons of carbon per hectare (tC ha-1), using IPCC's default carbon fraction (0.47) when the values were reported in tons of dry matter (t d.m. ha^{-1}). All information related to C stock estimates, such as information on land use, number of sampling units, plot size, the allometric equation used, etc., were also recorded. For full detail please check BaseDeDatos_v5[146] and C-STOCKS sheet of FREL TOOL[147]. The literature review employed the following criteria for compiling the reported value: • The publication reported data from direct measurements carried out in Costa Rica • Measurements were carried out after the year 2005 • Data were sufficiently disaggregated by reporting values of carbon stocks per land use categories and per carbon pool sampled • The publications included information on uncertainties related to the carbon stock estimates
Source of data of carbon stocks of non-Forest land uses	C stocks in these non-forest land uses were estimated as the average values reported by the selected studies. For full detail please check BaseDeDatos_v5 and C-STOCKS sheet of FREL TOOL. • **Cropland**: carbon stock values reported in selected studies showed high variability, depending on crop type (sugar cane, coffee, banana, cocoa, etc.). For this reason, the carbon stock data compiled were weighted by the surface area of the respective crops in Costa Rica to produce a single estimate of carbon stocks from cropland. • **Grassland:** carbon stocks were estimated as the average values reported in different carbon pools in the selected studies. • **Settlements and (non-forested) Wetlands:** no studies could be found reporting biomass values for these categories. It was assumed that their carbon stock is zero. • **Other Land:** studies were found reporting carbon stocks for *Paramo.* In the case of *Bare Soil,* it was assumed carbon stocks are zero.

[145] Cifuentes, M. (2008). Aboveground Biomass and Ecosystem Carbon stocks in Tropical Secondary Forests Growing in Six Life Zones of Costa Rica (Oregon State University). Retrieved from https://drive.google.com/file/d/1FsiTVc78EHcU0gQ4JfFJFSlPqesm3JFW/view?usp=sharing

[146] BaseDeDatos_v5.xlsx can be accessed at the following link: https://drive.google.com/file/d/1d6QqYQci7_Qo7DJhS5eOKgCqLFDX-rFX/view?usp=sharing

[147] The FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing

Methods for estimating C stocks and Emission Factors	
	• **Above ground biomass (AGB)**: Above ground of forest biomass is calculated as 47% of the biomass dry weight of standing trees in the forest, which is calculated using allometric equations. Aboveground biomass of each measured tree was estimated using Chave et al., (2005)[148] moist forests allometric equation as follows: $$AGB = \exp\left(-2.977 + \ln\left(\rho * DBH^2 * HT\right)\right)$$ *Where:* *AGB: aboveground biomass (kg)* *ρ: wood specific gravity (g/cm³). Obtained from literature.* *DBH: Diameter at breast height (cm)* *HT: Tree height (cm)* AGB estimates at the tree level are then summed per plot, and extrapolated to a per hectare basis by applying a scaling factor of 10, which represents the proportion of a hectare (10,000 m²) that is occupied by the plot as follows: $$ScalingFactor = \frac{10{,}000m^2}{1{,}000m^2} = 10$$ *Where:* *10,000m²: Area of one hectare (m²)* *1,000m²: Area of INF-CR rectangular plot (20m x 50m)* • **Below ground biomass (BGB)**: BGB is derived directly from Cairns et al., (1997).[149] equation, to estimate C_{BGB} from C_{AGB} data: $$\mathrm{BGB} = \exp\left(-1.085 + 0.9256 * \ln\left(\mathrm{AGB}\right)\right)$$ Where: BGB: belowground biomass (t d.m. ha^{-1}) AGB: aboveground biomass (t d.m. ha^{-1}) This equation was applied to both, primary and secondary forests. • **C stocks of forest** lands corresponds to the area-weighted average of C stocks by C pool and strata. • **C stock changes** (ΔC) are estimated using the Stock-Difference Method by applying IPCC (2006) equation 2.5 (cf. Volume 2, Chapter 2, Section 2.2.1.).
Value applied in reference period:	
Carbon stocks in Primary forest	(see table below)
Carbon stocks in Secondary Forest	The table below shows the Bmax values used in the equations above to calculate $TAGB_t$ from the secondary forest stand age. (see table below)

Primary Forest type	Area-weighted average		
	t C_{AGB} ha^{-1}	t C_{DWB} ha^{-1}	t C_L ha^{-1}
Wet and Rain Forests	131	13.5	2.7
Moist Forests	93	13.2	2.2
Dry Forests	62	15.4	6.2
Mangroves	72	1.9	0.3
Palm Forests	52	1.6	0.3

Secondary Forest Type	B_{max} (t dry mass ha^{-1})
Wet and Rain Forests	445
Moist Forests	262
Dry Forests	155

[148] Chave J et al. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145: pp. 87-99.
[149] Cairns M.A., Brown S., Helmer E.H., and Baumgardner G.A. (1997). Root biomass allocation in the world's upland forests. Oecologia 111:1-11.

Carbon stocks of non-Forest land uses	

Non-forest land uses	Area-weighted average t C_{AGB} ha^{-1}
Permanent crop, wooded, cropland	16
Annual crop, wooded, cropland	0
Permanent crop, non-wooded, cropland	7
Annual crop, non-wooded, cropland	23
Grasslands, wooded	8
Grasslands, non-wooded	4
Paramos	35

QA/QC procedures applied

AGB in primary forest

SINAC implemented the following QA/QC procedures during the National Forest Inventory of Costa Rica (for further details please see Ministerio de Ambiente y Energía, 2015)[150]:

Fieldwork organization: SINAC organized the fieldwork by regions: North Pacific and Central Valley (PN-VC), Central Pacific and South Pacific (PS), North-Caribbean North Zone (ZN-CN), Central-South Caribbean (CC-CS), and complex sites (Talamanca mountain range). SINAC prepared terms of reference, describing each member of the field crew's roles and responsibilities. An experienced dendrologist was part of the work team, and a field manual was prepared for identifying, collecting, transport, and processing botanical samples. The Crew was trained before the start of fieldwork, and an Excel template was designed for data typing.

Fieldwork supervision: During the NFI implementation, the coordinator made field visits to supervise the crews' work. A photographic registry of each plot was made.

Registry of information: The field crew filed field forms and prepared reports of the activities. The crew chief and fieldwork director reviewed the field forms. The IFN steering committee did the final review. If the supervisor detected errors, omissions, or inconsistencies, the records were returned to the crew leader with observations for their correction or documenting the discrepancies; the dendrological inventory component coordinator reviewed questionable species identifications. Control procedures were applied to evaluate the coherence, integrity, and completeness of dasometric, dendrological, and positioning data.

Independent evaluation of forest inventory data quality: A separate crew evaluated the quality of forest inventory data. The independent team made field visits and re-measures 10% of the plots established by stratum, both in the pre-sampling and inventory phase.

Uncertainty associated with this parameter:

AGB's uncertainty in primary forests is derived from NFI sampling errors. Since belowground biomass is a function of aboveground biomass, the belowground biomass values have the same level of uncertainty as the aboveground biomass. Uncertainty from values DWB and L is derived from values identified in the scientific literature. The statistical uncertainty reported in these documents takes into consideration the sampling error. Therefore, the current version of the reference level only considers this error source.

Primary Forest type	Uncertainty (%) of aboveground biomass
Wet and Rain Forests	150%
Moist Forests	152%
Dry Forests	152%
Mangroves	93%
Palm Forests	81%

Non-forest land uses	Area-weighted average t C_{AGB} ha^{-1}

[150] Ministerio de Ambiente y Energía. (2015). Volumen 4 Marco conceptual y metodológico para la Inventario forestal nacional de Costa Rica. Retrieved from https://www.sirefor.go.cr/pdfs/Volumen4-MarcoC-Imprenta.pdf

		Permanent crop, wooded, cropland	71%
		Annual crop, wooded, cropland	0%
		Permanent crop, non-wooded, cropland	68%
		Annual crop, non-wooded, cropland	12%
		Grasslands, wooded	0%
		Grasslands, non-wooded	0%
		Paramos	2%

8.4 Estimated Reference Level

ER Program Reference level

Crediting Period year *t*	**Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)**	**If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)**	**If applicable, 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)**
2018	5,985,795	1,383,974	-4,784,051	NA	2,585,717
2019	5,985,795	1,383,974	-4,784,051	NA	2,585,717
2020	5,985,795	1,383,974	-4,784,051	NA	2,585,717
2021	5,985,795	1,383,974	-4,784,051	NA	2,585,717
2022	5,985,795	1,383,974	-4,784,051	NA	2,585,717
2023	5,985,795	1,383,974	-4,784,051	NA	2,585,717
2024	5,985,795	1,383,974	-4,784,051	NA	2,585,717

Calculation of the average annual historical emissions over the Reference Period

Costa Rica used the annual average historical emissions from deforestation and degradation, and annual average removals from enhancements of carbon stocks in forest remaining forests and reforestation during the proposed reference period (1998 to 2011), both of which were added for each year. The detailed equations to estimate these annual averages and assumptions made in calculations are included above. Because there was no clear trend line of emissions and of removals during the reference period 1998-2011, the baseline for the reporting period 2018-2024 was estimated as the average emissions of its reference period (i.e. 2,585,717 t CO2e yr^{-1}).

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

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

No adjustment was made to the average annual historical emissions over the reference period.

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

Not applicable.

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

As described in the ER-PD, Costa Rica has made important efforts to harmonize GHG reporting under the UNFCCC, including National GHG inventories and REDD+. These are described below and summarized in Table 16[151].

Consistency with the National GHG Inventory (INGEI):

The historical data mentioned in Section 3 and further described in Annex 4 were used to recalculate the years 2005, 2010 and 2012 of the 2012 GHG Inventory, included in Costa Rica's first BUR (2015). Due to time and resources constraints, only these inventory years were considered in the recalculations. The years 1990, 1995 and 2000 will be recalculated as well and reported in the country's next National Communication to the UNFCCC.
For the AFOLU sector and in relation to REDD+, the current GHG Inventory included the following sources and sinks:

- GHG emissions and CO_2 absorptions from carbon stock changes in biomass, dead organic matter and mineral soils, for managed lands;
- CO_2 and non-CO_2 emissions from biomass burning, in managed lands.

For the complete alignment of the GHG Inventory with the current FREL submission to the UNFCCC and RL to the FCPF Carbon Fund, the following inconsistencies remain (see Table 5):

- The current National GHG inventory comprises the years 2005, 2010 and 2012, while the reference level (RL) to the FCPF Carbon Fund covers 1998-2011.
- CH_4 and N_2O emissions from biomass burning in forests remaining forests were explicitly considered in the GHG inventory but not in the REDD+ RL. These estimates were derived from national statistics which are not spatially explicit and only cover 2011-2013[152]. Hence, for the REDD+ RL, there was not enough information to complete the time series for 1998-2011.
- Forest plantations were identified as part of forests remaining forests in the GHG inventory. For the estimation of C stock changes in plantations, ancillary information from the 2014 Agricultural Census was used specifically for 2012.
- Any differences in methods and data found are due to data gaps and the use of specific databases for building estimates for specific years. This has been necessary due to the lack of a continuous forest monitoring system in the country. Costa Rica has now built this system and methods and data for the GHG inventory, REDD+ MRV, and NAMA MRV will be streamlined.

Consistency with REDD+ FREL submitted to the UNFCCC:

Costa Rica's 2016 FREL submission to the UNFCCC includes two historical reference periods: 1986-1996 and 1997-2009. For the FCPF Carbon Fund and the ER-Program, Costa Rica proposed a 1998-2011 Reference Level.

The same REDD+ activities, greenhouse gases and C pools, AD and EF estimating methods and data sources, methods for mapping land use and emission calculation tools, were used in estimating annual average emission and removal of both Costa Rica FREL (see Table 5). For the UNFCCC FREL 2010-2025 uncertainty was not estimated. Likewise, uncertainty was not analyzed by the Technical Team of Experts of UNFCCC. However, uncertainty for the Carbon

[151] MINAE, 2019. Technical Annex of the Republic of Costa Rica, in accordance with the provisions of Decision 14 / Cp.19. 64pp.
[152] Additional information for different periods is available here: http://www.sirefor.go.cr/?page_id=1051

Fund Reference Level and its 2018-2019 monitoring period was estimated using Approach 2 of the IPCC 2006 Guidelines employing Monte Carlo simulations, and the uncertainties are reported in terms of 90% confidence intervals.

The methodology for estimating emissions of the FOLU sector in the Biennial Update Report is partially consistent with the methodology for estimating REDD+ results (see Table 5). The differences between methodologies are that the UNFCCC 2016 FREL includes:

- FOLU Sector emissions include Harvested Wood Products, and CH_4 and N_2O emissions.
- Dead wood and litter carbon pools are excluded.

Table 22: Overview of the methods used to obtain the average annual emissions and removals for the Carbon Fund Reference Level (1998-2011) for the monitoring period 2018-2019, compared with those used to calculate the FREL/FRL submitted to the UNFCCC in 2016, and the FOLU emissions of INGEI in the latest Biennial Update Report (2015)[153].

Parameters	FREL for 2010-2025 submitted by Costa Rica to the UNFCCC in 2016	Costa Rica's Carbon Fund Reference Level (1998-2011) for the 2018-2019 monitoring period	Costa Rica's INGEI FOLU emissions on the Biennial Update Report (2015)
IPCC Guidelines applied	IPCC 2006		
REDD+ activities	Emission reductions from deforestation Enhancement of forest C stocks		Emission reductions from deforestation Enhancement of forest C stocks Harvested Wood Products
Greenhouse gases	Methane (CH_4) and nitrous oxide (N_2O) were excluded.		Methane (CH_4) and nitrous oxide (N_2O) are included.
C pools included	Above-ground biomass (AGB) Below-ground biomass (BGB) estimated following Cairns et al. (1997)[154] Dead wood (DW) Litter (L)		Above-ground biomass (AGB) Below-ground biomass (BGB) estimated with IPCC default values.
Non anthropogenic emissions	Excluded		
Activity Data			
Representation of lands	Forest Lands: Wet and rain forest; Moist forest; Dry forest; Mangroves; Palm Forest Croplands: Annual crops; Perennial crops Grassland Settlements Wetlands: Natural wetlands; Artificial wetlands Other lands: Paramo; Natural Bare soil; Artificial Bare soil		
Data sources	Remotely sensed data from four generations of the Landsat family (Landsat 4 TM, Landsat 5	Remotely sensed data from Landsat 8 OLI/TIRS (see section 3, Annex 4 of this monitoring report).	

[153] MINAE, 2019. Technical Annex of the Republic of Costa Rica, in accordance with the provisions of Decision 14 / Cp.19. 64pp.
[154] Cairns, M. A., Brown S., Helmer E. H., and Baumgardner G. A., 1997. Root biomass allocation in the world's upland forests. Oecologia 111: pp. 1-11.

Parameters	FREL for 2010-2025 submitted by Costa Rica to the UNFCCC in 2016	Costa Rica's Carbon Fund Reference Level (1998-2011) for the 2018-2019 monitoring period	Costa Rica's INGEI FOLU emissions on the Biennial Update Report (2015)
	TM, Landsat 7 ETM and Landsat 8 OLI/TIRS).		
Mapping Land Use	The land use maps were created using the methodology detailed in Agresta et al (2015)[155], and postprocessing procedures described in MINAE (2016)[156] (see section 3, Annex 4 of this monitoring report)		
Methods for estimating AD	AD was estimated by combining all land use maps created for 1985/86-2013/14 in a Geographical Information System (GIS) and then extracting the values of the areas that remained in the same category or converted to other land use categories from the combined set of multi-temporal data. The results of this operation are reported in land use change matrices prepared for each measurement period in the sheets "LCM 1986-91", "LCM 1992-97", "LCM 1998-00", "LCM 2001-07", "LCM 2008-11", and "LCM 2012-13" of the spreadsheets in FREL TOOL CR.	AD was estimated by combining land use maps in a Geographical Information System (GIS) and then extracting the values of the areas that remained in the same category or converted to other land use categories from the combined set of multi-temporal data. The results of this operation are reported in land use change matrices of the spreadsheets in FREL TOOL CR[157].	
Emission Factors			
Data sources for estimating EF	National Forest Inventory (NFI)[158] preliminary results including a 289-plot representative sample was used for the estimation of forest C stocks. Non-Forest lands C stocks were estimated as the average values reported by the selected studies (110 publications)[159].		C stocks in above-ground biomass (AGB) of Forests Lands were estimated using the asymptotic value of the equations

[155] Agresta, Dimap, Universidad de Costa Rica, Universidad Politécnica de Madrid, 2015. Informe Final: Generating a consistent historical time series of activity data from land use change for the development of Costa Rica's REDD plus reference level: Protocolo metodológico. Informe preparado para el Gobierno de Costa Rica bajo el Fondo de Carbono del Fondo Cooperativo para el Carbono de los Bosques (FCPF). 44 p

[156] Ministry of the Environment and Natural Resources of Costa Rica. (2016). Modified REDD+ Forest reference emission level/forest reference level (FREL/FRL). COSTA RICA. SUBMISSION TO THE UNFCCC SECRETARIAT FOR TECHNICAL REVIEW ACCORDING TO DECISION 13/CP.19. Retrieved from https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf

[157] The FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing

[158] Programa REDD/CCAD-GIZ - SINAC. 2015. Inventario Nacional Forestal de Costa Rica 2014-2015. Resultados y Caracterización de los Recursos Forestales. Preparado por: Emanuelli, P., Milla, F., Duarte, E., Emanuelli, J., Jiménez, A. y Chavarría, M.I. Programa Reducción de Emisiones por Deforestación y Degradación Forestal en Centroamérica y la República Dominicana (REDD/CCAD/GIZ) y Sistema Nacional de Áreas de Conservación (SINAC) Costa Rica. San José, Costa Rica. 380 p. Available at: http://www.sirefor.go.cr/?p=1170

[159] Costa Rica Carbon Density Database can be accessed in the following link: https://drive.google.com/file/d/1LJ8pbd0EuiVoS7JuMc8ps_OwlD12MUuH/view?usp=sharing

Parameters	FREL for 2010-2025 submitted by Costa Rica to the UNFCCC in 2016	Costa Rica's Carbon Fund Reference Level (1998-2011) for the 2018-2019 monitoring period	Costa Rica's INGEI FOLU emissions on the Biennial Update Report (2015)
Primary forest AGB	C stocks per hectare were estimated as the area-weighted average C stock value from the selected sources, using the sampled area as weighting criterion. For Mangroves and Palm Forests, a simple arithmetic mean was calculated. More detail in Ministry of the Environment and Natural Resources of Costa Rica. (2016), section 4.4.2, Table 8.		developed by Cifuentes (2008)[160]
Secondary forest AGB	C stocks in total net above-ground biomass (T_AGB) of Wet and Rain Forests, Moist Forests and Dry Forests were estimated using the equations developed by Cifuentes (2008) for Costa Rican secondary forests. For Mangroves and Palm Forests, a linear function was assumed for estimating C stocks as a function of age. More detail in Ministry of the Environment and Natural Resources of Costa Rica. (2016), section 4.4.2, page 39.		
Methods for estimating EF	C stock changes (ΔC) were estimated using the Stock-Difference Method by applying IPCC (2006) equation 2.5 (cf. Volume 2, Chapter 2, Section 2.2.1.). More detail in Ministry of the Environment and Natural Resources of Costa Rica. (2016), section 4.4.3.		
DA and EF integration tool			
DA and EF integration tool	The annual average emissions from deforestation and annual removals from enhancements of forest C stocks were calculated using in FREL TOOL CR[161].		The annual average emissions from deforestation and annual removals from enhancements of forest C stocks were calculated using a spreadsheet developed by the IMN.
Uncertainty			
Uncertainty estimate	For the FREL 2010-2025 uncertainty was not estimated. Likewise, uncertainty was not analyzed by the Technical Team of Experts of UNFCCC.	Uncertainty for the Carbon Fund Reference Level and its 2018-2019 monitoring period was estimated using Approach 2 of the IPCC 2006 Guidelines employing Monte Carlo simulations, and the uncertainties are reported in terms of 90% confidence intervals	Uncertainty of INGEI, including FOLU sector emissions is estimated using the Error Propagation Method, following approach 1 of the IPCC guidelines.

[160] Cifuentes, M. 2008. Aboveground Biomass and Ecosystem Carbon Pools in Tropical Secondary Forests Growing in Six Life Zones of Costa Rica. Oregon State University. School of Environmental Sciences. 2008. 195 p.
[161] 2016.07.10 - FREL & MRV TOOL CR MapaIMN15v3.xlsx
https://drive.google.com/file/d/1ZV7eYpA5ab75VLKLF3KGp8rfPJ_U3wpz/view?usp=sharing

9 APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

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

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The processes for collecting, processing, consolidating, and reporting GHG data and information employed during the monitoring period will be identical to the ones used for the construction of the reference level. Costa Rica will monitor the same activities and carbon pools and will implement these same procedures for future monitoring events.

SIMOCUTE is responsible for establishing the methods and protocols to generate the activity data and emission factors. Specifically:

- **Obtaining activity data (AD):** Instituto Meteorológico Nacional (IMN) has produced to date all land use cover maps and national GHG inventories in Costa Rica. The REDD+ Secretariat has been the entity responsible for developing the land use cover maps for the historical series that were used to develop the FRL/FREL submitted to the UNFCCC.
- **Obtaining emission factors (EFs):** SINAC is responsible for Costa Rica's NFI, which determines regularly the forest stocks in the country. The NFI outcomes are used to develop emission factors for Costa Rica's REDD+ MRV. SINAC will update the NFI to allow future resampling of a portion of the existing plots, with the support of US Forest Service (USFS) and FAO, which will consist on a resampling of a portion of SIMOCUTE's 10,588 sampling plots. Costa Rica intends to start as soon as possible with the measurement of 441 sampling points over a 5-year period to estimate biomass transitions [162].
- **Estimating emissions and sinks:** IMN, responsible for the national GHG inventories in Costa Rica, maintains the capacity to estimate GHG from AFOLU (agriculture, forestry, and other land use) and LULUCF (land use, land use change, and forestry).
- **Reporting:** Technical reports and annexes on REDD+ are developed by the REDD+ Secretariat and supported by IMN experts estimating emissions and sinks. These include reports to the FCPF Carbon Fund (FC), safeguards reports, and BURs for payment for performance under REDD+. The results from these reports then undergo a verification process by external reviewers and the REDD+ secretariat along with the IMN work team must adjust the FREL/FRL as needed.

To calculate the average annual historical emissions over the reference period, Costa Rica follows an activity-based approach where emissions and removals are estimated based on spatially explicit gross activity data and on net emission factors. Activity data is entered in land use matrices (see below) to ensure representation of all land use transitions and avoid double counting or omissions.

[162] MINAE, 2019. Technical Annex of the Republic of Costa Rica, in accordance with the provisions of Decision 14 / Cp.19. 64pp. Retrieved from https://unfccc.int/sites/default/files/resource/4863_3_iba-2019-anexotecnico_Edited.pdf .

	FL	LCFL	CL	GL	SL	WL	OL
FL	*CO*	*NA*	*DF.1*	*DF.1*	*DF.1*	*DF.1*	*DF.1*
LCFL	*EC.3*	*EC.2*	*DF.2*	*DF.2*	*DF.2*	*DF.2*	*DF.2*
CL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
GL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
SL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
WL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*
OL	*NA*	*EC.1*	*NA*	*NA*	*NA*	*NA*	*NA*

__FL__, Forest Land; __LCFL__, Land Converted to Forest Land; __CL__, Cropland, GL, Grassland; __SL__, Settlements; __WL__, Wetlands; __OL__, Other Land; __CO__, Conservation of forest C stocks; __EC__, Enhancements of forest C stocks (.1, EC in conversions of non-forest land to forest land; .2, EC in LCFL remaining LCFL; .3, EC in LCFL converting to FL); __DF__, Deforestation (.1, DF of old-growth forests; .2, DF of secondary forests); __NA__, Not Applicable in the REDD+ context.

Once AD and EFs for the forest that remain forests and forest cover change are generated and the corresponding GHG fluxes estimated with excel-based calculators, the uncertainty of the estimates is assessed by IMN and technical advisors from academia as needed (Figure 3).

To develop NFMS methods and protocols, SIMOCUTE follows the UNFCCC AFOLU requirements for monitoring land use cover emissions and establishes technical working groups to determine the procedures to implement methodologies and protocols, as well as to update them if needed. These technical working groups are conformed by experts from the institutions involved in the monitoring of ecosystems and land use / land cover.

The key elements of the SLMS and the NFI, including the source of data, the forest area covered, and the frequency of monitoring can be found in the Technical Annex Document[163]. There are QA/QC procedures for the AD and FE calculation as follows:

- **Activity Data:** The QA/QC procedures applied during the calculation of AD for the reference and monitoring period are summarized in Tables 2, 3, 6, and 7, further information may be found in Agresta (2005)[164], Ortiz-Malavassi (2017)[165], and Aguilar (2020)[166].
- **Emission Factors:** The QA/QC procedures applied during the calculation of EF for deforestation and degradation are summarized in Tables 4 and 5, further information may be found in Ministerio de Ambiente y Energía (2015)[167], Rodriguez (2018)[168], Coto (2018)[169], and Obando (2019)[170].

Costa Rica's first National Forest Inventory (NFI) was finished in 2015, under the supervision of SINAC. The NFI plots have been found to pose challenges for SINAC to conduct forest change assessments over time because of an uneven

[163] MINAE, 2019. Technical Annex of the Republic of Costa Rica, in accordance with the provisions of Decision 14 / Cp.19. 64pp. Retrieved from https://unfccc.int/sites/default/files/resource/4863_3_iba-2019-anexotecnico_Edited.pdf .

[164] Agresta, Dimap, Universidad de Costa Rica, Universidad Politécnica de Madrid. 2015. Final Report: Generating a consistent historical time series of activity data from land use change for the development of Costa Rica's REDD plus reference level: Methodological Protocol. Report prepared for the Government of Costa Rica under the Carbon Fund of the Forest Carbon Partnership (FCPF). 44 pp. https://www.dropbox.com/s/ygjw6zq00a1qtbm/Informe_tecnico_feb_2015.pdf?dl=0

[165] Ortiz-Malavassi, E. (2017). Evaluación Visual Multitemporal (EVM) del Uso de la tierra, Cambio en el Uso de la Tierra y Cobertura en Costa Rica Zonas A y B Tarea 1: Estimación del área de cambio de uso de la tierra durante el periodo 2014-2015. Retrieved from https://drive.google.com/file/d/1GXdN43f-DNKelkM8y7gBLrKou-f7LI-G/view?usp=sharing

[166] Aguilar, L. (2020). Evaluación Visual Multitemporal para la determinación de la degradación forestal para los periodos 2014-2015-2017-2019 y determinación de datos de referencia para periodo 2017-2019. Tercer Informe. Retrieved from https://drive.google.com/file/d/1ERutZo6vNI6MXUCmlrky7wiaeOqOLMqh/view?usp=sharing

[167] Ministerio de Ambiente y Energía. (2015). Volumen 4 Marco conceptual y metodológico para la Inventario forestal nacional de Costa Rica. Retrieved from https://www.sirefor.go.cr/pdfs/Volumen4-MarcoC-Imprenta.pdf

[168] Rodríguez, J. (2018). INFORME FINAL DE CONSULTORÍA Estudio de parcelas temporales para estimar el stock de carbono en bosques intactos, degradados y altamente degradados en zona A. (Contrato N°020-2018-REDD). Retrieved from https://drive.google.com/file/d/1dSyL8Dldwym5VN1jXpnAbmPovUW3AiTu/view?usp=sharing

[169] Coto, O. (2018). INFORME FINAL DE CONSULTORÍA. Estudio de parcelas temporales para estimar el stock de carbono en bosques intactos, degradados y altamente degradados en zona B. (Contrato N° 019-2018-REDD). Retrieved from https://drive.google.com/file/d/1svYPJGEoBHpLn72sg4ejpf6uZkp6lllM/view?usp=sharing

[170] Obando, G. (2019). COORDINACIÓN GENERAL DE LA IMPLEMENTACIÓN DEL PLAN DE MEJORA DEL NIVEL DE REFERENCIA. Tercer Informe de Consultoría N ° 016-2018-REDD. Retrieved from https://drive.google.com/file/d/1MEHZ6dvQKY52X58UtlG02o4Uw9x1HV6v/view?usp=sharing

plot distribution among forest strata[171] and thus, SINAC is currently evaluating changes to the NFI structure through redistributing the plots to enhance compatibility with SIMOCUTE.

Costa Rica already conducted a monitoring event and estimated emission reductions as part of the ER-Program. The methods and data employed are identical to the ones used for the construction of the reference level. The country will implement these same procedures for future monitoring events of ER Program. The FREL and Degradation tools contain a list of values and parameters (including their source and associated level of uncertainty) used to calculate the reference level and that are employed during the MRV. These values will not change during the term of the ERPA.

LINE DIAGRAM

The diagrams below show a step-by-step description of the measurement and monitoring approach for establishment of the Reference Level and estimating Emissions and Emissions reductions during the Monitoring / Reporting Periods for estimating the emissions and removals from the Sources/Sinks, Carbon Pools and greenhouse gases selected in the ER-PD (Figure 2).

Costa Rica has developed a tool to estimate emission and removals from deforestation and reforestation - FREL & MRV TOOL CR.xlsx[172], and other for the estimate of emission and removals from degradation in permanent forest lands – Herramienta-degradacion.xlsx[173].

FREL tool: Details of FREL tool can be found in START spreadsheet, and its manual (Manual de la Herramienta FREL & MRV Tool – UNFCCC.pdf in Spanish[174]). The tool is organized in the following sections:

Setting sections that must not be modified by users:

xi. START: This spreadsheet explains the general information of the Tool: i. name and contact information of the person who made the last modification of the Tool, ii. date of the changes and iii. keyword used to lock spreadsheets.

xii. FREL&FRL: In this spreadsheet the user can recalculate the FREL/FRL by selecting i. carbon gases and reservoirs to be included in the FREL/FRL; ii. REDD + activities to be included in the FREL/FRL; iii. the years of the historical reference period of the FREL/FRL.

xiii. C-STOCKS: The objective of this spreadsheet is to calculate the carbon stocks (in tCO_2-e ha^{-1}) of the land use categories represented in the Land Cover Maps (MCS) of Costa Rica. The calculation is done separately for each gas and carbon pool, whether or not it is included in the FREL/FRL. The spreadsheet also reports uncertainty values, at 90% or 95%, associated with estimates of average carbon existence. The calculations of these uncertainty values are made in a separate Excel file ("Carbon Database> 4. Carbon Densities"[175]) using the IPCC uncertainty propagation method (Equation 3.1 and 3.2 of IPCC-GL, 2006 - Volume 2). At the end of the spreadsheet, all the data, parameters and default values used in the calculation of carbon stock estimates and their respective sources are listed.

xiv. REDD+ ACT: This spreadsheet defines REDD + activities in such a way that it is not possible to count the same source or the same GHG sink in more than one REDD + activity and ensuring, at the same time, that all GHG sources and sinks are considered in the analysis. The approach taken to meet this objective is to represent in a matrix of land use changes all possible transitions between land use categories and then assign each cell in the matrix to a single REDD + activity.

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[171] Recomendaciones para la Medición, Reporte, y Verificación (MRV) de REDD+. 2016. Report from the CDI, US Forest Service, and FAO UN-REDD. 33 pp.

[172] The FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing

[173] Degradation tool can be accessed in the following link: https://drive.google.com/file/d/1GG3Z_QMWBKGNRdXnF_TdWP1ipH9dX5iH/view?usp=sharing

[174] A copy of the FREL Tool Manual can be download at the following link: https://drive.google.com/file/d/14CsE_rpBBrEJgyUTplziKKsGGVm_YtL_/view?usp=sharing

[175] A copy of Carbon Densities database can be download at the following link: https://drive.google.com/file/d/1LJ8pbd0EuiVoS7JuMc8ps_OwlD12MUuH/view?usp=sharing

xv. LIST: This spreadsheet contains the drop-down lists that appear in the rest of the Tool's pages and additional information related to the stratification of Costa Rica's forests. No calculation is made on this sheet.

Input section:

xvi. LCM AAAA-AA: In this spreadsheet the activity data of the “AAAA-AA” period are reported, where “AAAA and AA” are the beginning (“AAAA”) and end (“AA”) years of the period. This is done by filling in a matrix of land use changes with all possible transitions. The structure of the matrix is identical to the matrix presented in the “REDD + ACT” spreadsheet, which allows the activity data to be related to REDD + Activities.
The “LCM AAAA-AA” spreadsheets are the only ones that must be filled in for REDD + monitoring. When activity data is entered in the matrices of the “LCM AAAA-AA” sheets, the Tool will automatically calculate the annual activity data (“AD AAAA” sheets) and annual emissions and removals (“ER AAAA” sheets) up to the “AA” year (= last year of the “AAAA-AA” period). The “FREL & FRL” sheet will be updated with the data calculated up to the “AA” year and the results of the mitigation actions (or emission reduction program) on the “RESULTS” sheet.

Calculation section:

xvii. AD AAAA: In this sheet the annual activity data are calculated from the values entered in the “LCM AAAA-AA” sheets. The calculation is made in matrices of land use changes and is based on the assumption that in the “AAAA-AA” period the areas converted annually are equal.

xviii. ER AAAA: These spreadsheets calculate GHG emissions and removals related to the land use change summarized by type of forest and REDD + activities. The calculation is performed automatically in each of the cells of the land use change matrices by multiplying the activity data by their corresponding emission factors. The activity data are the values calculated in the matrices of the “AD AAAA” spreadsheets. The emission factors are calculated as the difference between the carbon contents existing at the beginning and end of the year, taking the carbon stock values of the “C-STOCKS” spreadsheet.

Results sections:

xix. RESULTS: This spreadsheet calculates and shows the results of the mitigation action. Results are calculated considering the same gases, carbon reservoirs, emission factors and REDD + activities that were included in the FREL / FRL. The calculation of the results is simply the difference between the actual emissions / removals and the emissions / removals of the FREL/FRL.

xx. CHARTS: This spreadsheet contains graphs and tables that were included in the FREL / FRL description documents of Costa Rica that were submitted to the UNFCCC (MINAE, 2016). The content of this sheet is informative and there are no parameters that the user can change (except the working language) or calculations that are not performed on other spreadsheets.

Uncertainty analysis are performed in a separated tool using Monte Carlo simulation as described in section 5.

Degradation tool: Costa Rica used a methodology of visual interpretation of high-resolution images to detect changes in the canopy of permanent forest areas to estimate emissions and removals from degradation. This analysis resulted in a database of canopy cover percentages in 4,377 points in forest lands of Costa Rica for several years. Details of the Degradation tool can be found in Winrock International, (2018)[176]. The tool facilitates the following calculations:

- Segregation of interpretation points between anthropic and natural carbon flux areas to eliminate natural changes from emissions accounting since the ER program cannot control them.
- Calculation of the number of points in each forest state transition. In this step, the canopy interpretation assessment of the three forest status classes of the initial year and the final year of the monitoring period are classified. The three classes of forest status are: a. Intact: forest areas with canopy percentage between 85-100%; b. Slightly degraded: forest areas with canopy percentage between 60-85%; c. Very degraded: forest areas with canopy percentage less than 60%.
- Extrapolate the area of each transition of forest states. This step is necessary to extrapolate the carbon flows detected at the interpretation points to the entire permanent forest area for the monitoring period.

[176] Winrock International. (2018). Ejercicio : estimación de emisiones por actividades en bosques que permanecen como tales. Retrieved from https://drive.google.com/file/d/1Mk8MACXEKDROXQg2UP7t4FDqQmc8Q5S9/view?usp=sharing

- Calculation of the average canopy percentage for each forest state. In this step, the tool calculates the average canopy percentage of each forest state for the beginning and the end of the monitoring period.
- Estimation of carbon fluxes (emissions and removals) of each type of transition is the final step. The tool uses the relationship between the percentage of canopy cover and biomass to estimate carbon fluxes in each transition from forest state.

The Degradation tool is organized as follows:

viii. Descripcion_Variables: This sheet contains descriptions of the High-Resolution Image Visual Interpretation Analysis database attributes. Take note of the attributes *Arbol+Palma_AAAA* variables. These attributes show the percentage of canopy cover in the initial and final year of the monitoring period.

ix. Base_de_Datos: This sheet contains the database for the visual interpretation of high-resolution images.

x. Resumen_de_puntos: This sheet calculates the number of points and extrapolates the area for each transition from the forest state.

xi. Deg_ems_antro_RP_AA-AA: This sheet calculates the average canopy percentage of each forest state and the anthropic carbon fluxes (emissions and removals) of each type of transition for the Reference Period.

xii. Deg_ems_nat_RP_AA-AA: This sheet calculates the average canopy percentage of each forest state and the natural carbon fluxes (emissions and removals) of each type of transition for the Reference Period.

xiii. Deg_ems_antro_MP_AA-AA: This sheet calculates the average canopy percentage of each forest state and the anthropic carbon fluxes (emissions and removals) of each type of transition for the Monitoring Period.

xiv. Deg_ems_nat_MP_AA-AA: This sheet calculates the average canopy percentage of each forest state and the natural carbon fluxes (emissions and removals) of each type of transition for the Monitoring Period.

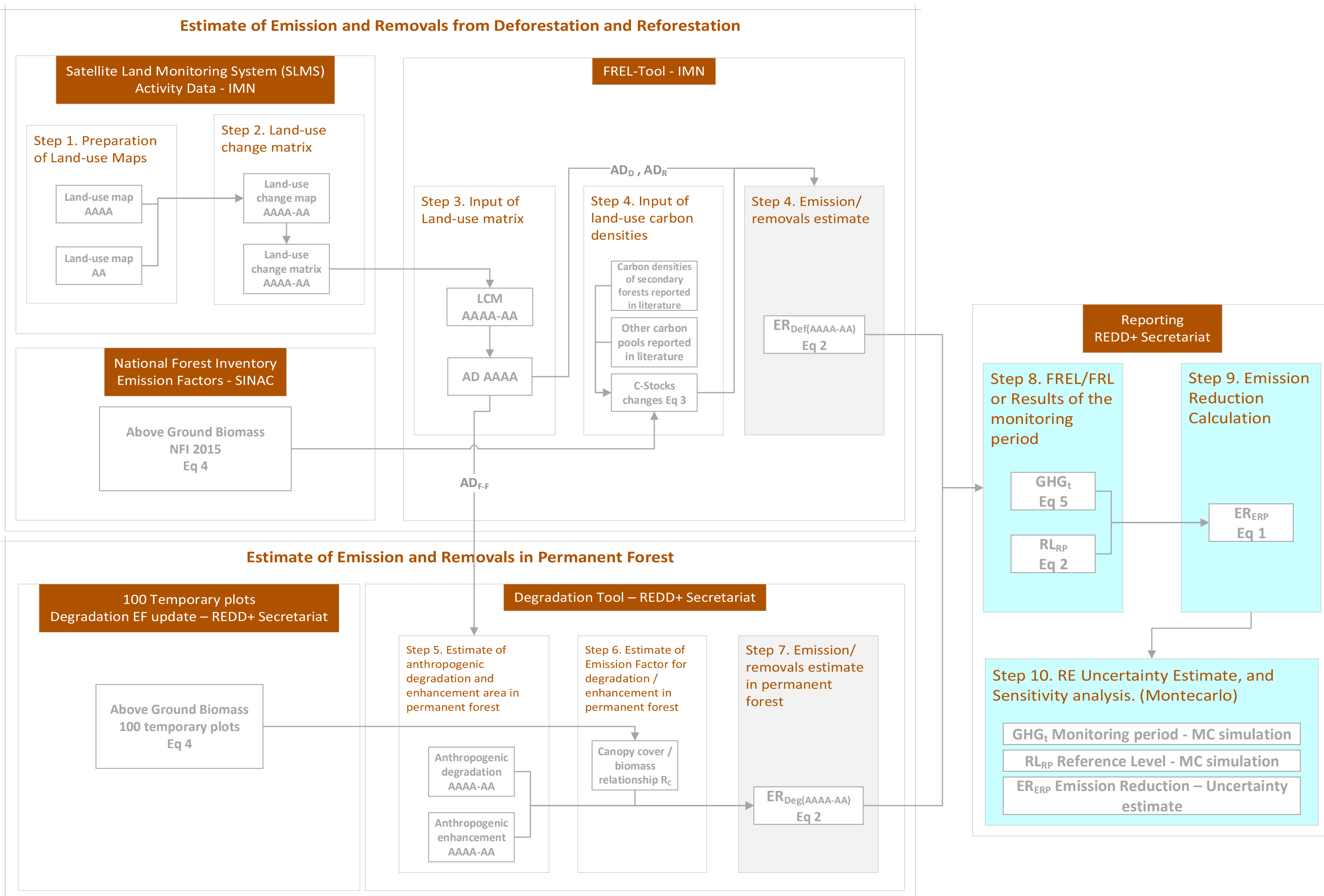

Figure 9: Step-by-step description of the measurement and monitoring approach applied for establishment of the Reference Level and estimating Emissions and Emissions reductions during the Monitoring / Reporting Periods for estimating the emissions and removals from the Sources/Sinks, Carbon Pools and greenhouse gases selected in the ER-PD of Costa Rica. This line diagram includes the update of the emission factors for degradation for the main forest types in the country (wet and rain forests, moist forests, dry forests, mangrove forests, and palm forests). This update is based on the 100 temporary plots sampled for aboveground biomass in 2018-2019.

CALCULATION STEPS

Emission reduction calculation

$$ER_{ERP,t} = RL_{RP} - GHG_t$$ **Equation 7**

Where:

ER_{ERP}	=	Emission Reductions under the ER Program in year t; $tCO_2e*year^{-1}$.
RL_{RP}	=	Gross emissions of the RL from deforestation and degradation over the Reference Period; $tCO_2e*year^{-1}$. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.
GHG_t	=	Monitored gross emissions from deforestation at year t; $tCO_2e*year^{-1}$;
T	=	Number of years during the monitoring period; dimensionless.

Reference Level (RL_t)

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

$$RL_{RP} = \frac{\sum_{t=1}^{RP} ER_{RA_t}}{RP} = \frac{\sum_{t=1}^{RP}\sum_{i=1}^{I}\left(AD_{RA_{i,t}} * EF_{RA_{i,t}}\right)}{RP}$$

Equation 8

Where:

ER_{RA_t}	=	Emissions or removals associated to REDD+ activity *RA* in year *t*; tCO_2-e yr^{-1}
$AD_{RA_{i,t}}$	=	AD associated to REDD+ activity *RA* for the land use transition *i* in year *t*; ha yr^{-1}
$EF_{RA_{i,t}}$	=	EF associated to REDD+ activity *RA* applicable to the land use transition *i* in year *t*; tCO_2-e ha^{-1}
RP	=	Reference Period in years
i	=	A land use transition represented in a cell of the land use change matrix; dimensionless
I	=	Total number of land use transitions related to REDD+ activity *RA*; dimensionless
t	=	A year of the historical period analyzed; dimensionless

Deforestation and Reforestation Activity Data (**AD_D** and **AD_R**) are calculated differently from Degradation and Enhancement Activity Data (**AD_{Deg}** and **AD_E**). Deforestation and Reforestation ADs result from the cartographic comparison of land-use maps from the beginning and end of the monitoring period. The Degradation and Enhancement DAs result from the sample-based estimation of canopy change area in permanent forest lands. Below are the equations used to calculate these parameters:

Activity Data of Deforestation (AD_D)	$AD_{D_{i,t}} = \left|D_{i,t}\right| * 0.81$, **Equation 2.1**	Where $\left|D_{i,t}\right|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Activity Data of Reforestation (AD_R)	$AD_{R_{i,t}} = \left|R_{i,t}\right| * 0.81$, **Equation 2.2**	Where $\left|R_{i,t}\right|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Forest remaining forests (AD_{F-F})	$AD_{F-F_{i,t}} = \left|F - F_{i,t}\right| * 0.81$, **Equation 2.3**	Where $\left|F - F_{i,t}\right|$ is the count of pixels of the land-use transition *i* in year *t*, dimensionless; and 0.81 is the pixel size in Hectares (ha).
Activity Data of Degradation (AD_{Deg})	$AD_{Deg_{i,t}} = \frac{\left|Deg_{i,t}\right|}{N} * \sum_{i=1}^{I} AD_{F-F_{i,t}}$ **Equation 2.4**	Where $\left|Deg_{i,t}\right|$ is the count of sampling points where canopy change decrease (dimensionless), *N* is the total of sampling points (dimensionless), and

		$\sum_{i=1}^{I} AD_{F-F_{i,t}}$ is the total area of permanent forest (in hectares – ha) in the monitoring period.
Activity Data of Permanent Forest Regeneration (AD_E)	$AD_{E_{i,t}} = \frac{\lvert E_{i,t} \rvert}{N} * \sum_{i=1}^{I} AD_{F-F_{i,t}}$ **Equation 2.5**	Where $\lvert E_{i,t} \rvert$ is the count of sampling points where canopy change increase (dimensionless), *N* is the total of sampling points (dimensionless), and $\sum_{i=1}^{I} AD_{F-F_{i,t}}$ is the total area of permanent forest (in hectares – ha) in the monitoring period.

EFs were determined from C stocks. C stock changes (ΔC) were estimated using the Stock-Difference Method by applying IPCC (2006) equation 2.5 (cf. Volume 2, Chapter 2, Section 2.2.1.). All results were multiplied by the stoichiometric ratio 44/12, as follows:

$$\Delta C = \frac{(C_{t2} - C_{t1})}{(t2 - t1)} * 44/12$$ **Equation 9**

Where:

ΔC	=	C stock changes associated to the land use transition *i* in year *t*; tCO_2-e ha^{-1}
C_{t1}	=	C stock at time *t1*, t CO_2 ha^{-1} *t1* in all cases was the 1st of January of each year *t*, *i.e.* C_{t1} is the C stock per hectare existing at the beginning of the year, before the conversion occurs. The estimated values are reported in the column K of the sheets "ER AAAA" (where "AAAA" stands for the year *t*) in the FREL TOOL.
C_{t2}	=	C stock at time *t2*, t CO_2 ha^{-1} *t2* in all cases was the 31st of December of each year *t*, *i.e.* C_{t2} is the C stock per hectare existing at the end of the year, after the conversion occurred. The estimated values are reported in the lines 19[177] and 20[178] of the sheets "ER AAAA" (where "AAAA" stands for the year *t*) in the FREL TOOL.
t2-t1	=	In all cases the C stock changes were estimated annually, *i.e. t2-t1* = 1 year.
44/12	=	Conversion of C to CO_2

Forest C is determined from the NFI biomass data, converted to carbon as follows:

$$C_t = \sum_{j,i} (B_{tot}) \text{ x CF}$$ **Equation 10**

Where:

B_{tot}	=	Total biomass stock for the land use category *LU*; tCO_2-e ha^{-1}. Total biomass is equivalent to the sum of all biomass pools: $B_{tot} = B_{AGB} + B_{BGB} + B_{DW} + B_L$ Where: AGB is above-ground biomass for land use category *LU*; tCO_2-e ha^{-1} BGB is below-ground biomass for land use category *LU*; tCO_2-e ha^{-1} DW is dead wood biomass for land use category *LU*; tCO_2-e ha^{-1} L is litter biomass for land use category *LU*; tCO_2-e ha^{-1}
CF	=	Carbon fraction of dry matter in tC per ton dry matter. The value used is: **0.47** is the default for (sub)tropical forest as per IPCC AFOLU guidelines 2006, Table 4.3.

[177] The C stock values reported in line 19 represent total C stocks existing in secondary forest and tree plantation at the end of the first year at which they meet the definition of "Forest", i.e., 4 years for all forest strata and 8 years for dry forests. These values are used to estimate ΔC in conversions of non-Forest land use categories to Forest land and conversions of other land use categories to permanent crops.

[178] The C stock values reported in line 20 represent total C stocks existing in the land use categories at the end of the year. They are used to estimate ΔC in all land use transitions, except conversions of non-Forest land use categories to Forest land and conversion of other land use categories to permanent crops.

Carbon stocks of non-Forest land uses are estimated as the average values reported by the selected studies:

- *Cropland:* carbon stock values reported in selected studies showed high variability, depending on crop type (sugar cane, coffee, banana, cocoa, etc.). For this reason, the carbon stock data compiled were weighted by the surface area of the respective crops in Costa Rica to produce a single estimate of carbon stocks from cropland.
- *Grassland:* carbon stocks were estimated as the average values reported in different carbon pools in the selected studies.
- *Settlements and (non-forested) Wetlands:* no studies could be found reporting biomass values for these categories. It was assumed that their carbon stock is zero.
- *Other Land:* studies were found reporting carbon stocks for *Paramo.* In the case of *Bare Soil* it was assumed carbon stocks are zero.

Additional details on AD, EF, and calculations in the reference level and monitoring period are available in Section 3 and Annex 4 of this monitoring report.

Monitored emissions (GHG_t)

Annual gross GHG emissions over the monitoring period in the Accounting Area ($\mathrm{GHG_t}$) are estimated as the sum of annual change in total biomass carbon stocks ($\Delta \mathrm{C_{B_t}}$).

$$\mathrm{GHG_t} = \frac{\sum_t^T \Delta \mathrm{C}_t}{\mathrm{T}} \quad \textbf{Equation 11}$$

Where:

$\Delta \mathrm{C_t}$	=	Annual change in total biomass carbon stocks at year t; tC*year^{-1}
T	=	Number of years during the monitoring period; dimensionless.

Changes in total biomass carbon stocks are calculated following Equation 3 above.

PARAMETERS TO BE MONITORED

The country will monitor the following parameters during the Monitoring Period (tables 17 and 18):

Table 23: Source of Activity Data and description of the methods for developing the data for estimate emissions from deforestation and carbon removals during the monitoring period.

Parameter:	**Activity Data of Deforestation (ADD) Eq. 2.1** **Activity Data of Reforestation (ADR) Eq. 2.2** **Forest remaining forests (ADF-F) Eq. 2.**
Description:	Deforestation: Hectares of forest that changed to non-forest land in a year summed each year (i) of the reference period. Reforestation: Hectares of non-forest that changed to forest land in a year, summed for each year (i) of the reference period. Forest remaining forests: Hectares of Forest remaining forests in a year, summed for each year (i) of the reference period
Data unit:	Hectares
Value monitored during this Monitoring / Reporting Period:	2018-2019: • Total anthropogenic deforestation: **9,403** ha yr^{-1} • Primary forest anthropogenic deforestation: **1,458** ha yr^{-1} • Secondary forest and tree plantation anthropogenic deforestation: **7,945** ha yr^{-1}

Source of data and description of measurement/calculation methods and procedures applied:	The construction of the AD for monitoring periods requires the following sources of data: • Remotely sensed data from Landsat 8 OLI/TIRS. • Mask of the country (in raster format) generated from map MCS 2013/14 • Land-use maps and Forest's type maps (MTB), prepared by AGRESTA (2015) to edit the results of the spectral classification of remotely sensed data and to further stratify the five forest categories "Wet and Rain Forests", "Moist Forests", "Dry Forests", "Mangroves" and "Palm Forests" into the sub-categories "primary forests" and "secondary forest. • The Global Forest Change project (Hansen et al., 2013) to fill in pixels without information in the mosaic of classifications for land-use maps. AD for land use change was estimated from the land use maps created for 1998-2011 and extracting multi-temporal values of the areas whose category remained unchanged and the areas that were converted to other land use categories. Deforestation and Reforestation ADs result from the cartographic comparison of land-use maps from the beginning and end of the monitoring period. Costa Rica has developed a tool to estimate emission and removals from deforestation and reforestation - FREL & MRV TOOL CR.xlsx[179]. Details of FREL tool can be found in START spreadsheet, and its manual (Manual de la Herramienta FREL & MRV Tool – UNFCCC.pdf in Spanish[180]). The frequency of monitoring of these paramaters is every two years.
QA/QC procedures applied:	According to the protocol described in Agresta *et al.* (2015.a)[181].
Uncertainty for this parameter	Uncertainties associated to AD are due to the production process of land-use maps. The uncertainties of the AD for land-use change activities (deforestation and reforestation) and forest remaining forest activities (degradation and enhancements in forest lands) come from the uncertainties associated with the process creating land use change maps from which the activity data are obtained. The accuracy assessment of the land-use change map is done following Olofsson et al.'s (2014)[182] guidelines.
Any comment:	**Process for managing and reducing uncertainty associated with this parameter**: The contribution of the AD is about 8.7% of aggregated uncertainty of Emission Reductions estimation (see section 5 of ER-MR). No process for managing or reducing AD uncertainty is being developed.

Table 24: Source of Activity Data and description of the methods for developing the data for estimate emissions from degradation during the monitoring period.

Parameter:	**Activity Data of Degradation (AD_{Deg}) Eq 2.4** **Activity Data of Permanent Forest Regeneration (AD_E) Eq. 2.5**

[179] The FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing

[180] A copy of the FREL Tool Manual can be download at the following link: https://drive.google.com/file/d/14CsE_rpBBrEJgyUTplziKKsGGVm_YtL_/view?usp=sharing

[181] Agresta, Dimap, Universidad de Costa Rica, Universidad Politécnica de Madrid, 2015.a. Final Report: Generating a consistent historical time series of activity data from land use change for the development of Costa Rica's REDD plus reference level: Methodological Protocol.Report prepared for the Government of Costa Rica under the Carbon Fund of the Forest Carbon Partnership (FCPF). 44 p.

[182] Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148, 42-57.

Description:	Degradation: Hectares of forest with a reduction of canopy cover during the monitoring period. Forest Enhancement: Hectares of forest with an increase of canopy cover during the monitoring period
Data unit:	Canopy cover percentage (%)
Source of data and description of measurement/calculation methods and procedures applied:	The forest degradation assessment is made on forest lands that remain as forest lands. The analysis of degradation is only performed on the area of forest remaining forest according to the land-use MCS 2012/13 map to avoid double-counting of baseline emissions between deforestation and forest degradation. This procedure avoided any measurements of degradation that were also accounted for under deforestation. Reference data to estimate Degradation AD is collected following Ortiz-Malavassi, (2017)[183]. The frequency of monitoring of these paramaters is every two years.
QA/QC procedures applied:	Ortiz-Malavassi (2017) prepared a land cover evaluation protocol to reduce the uncertainty of the land cover classification due to: a) the bias associated with the spatial registration of the reference image, b) the interpreter bias in the assignment of the land cover class; and c) interpreter variability. The protocol includes the operational definition of the canopy coverage with examples taken from high-resolution images and registration templates for Collect Earth Desktop.
Uncertainty for this parameter:	In the assessment of degradation level in forests remaining forests, it was assumed that there was no uncertainty associated with the visual interpretation of sample areas because this procedure employed visual classification of canopy cover using high resolution imagery. Uncertainty of changes in canopy cover to identify areas of degradation and forest enhancement from 1998-2011 vary depending on the forest type and the conversion class. It is based on the sampling error.
Any comment:	**Process for managing and reducing uncertainty associated with this parameter:** It is assumed that uncertainty will be reduced as higher-quality imagery becomes available on Google Earth and other sources. Given the low uncertainty of visual interpretation, efforts to reduce uncertainty are focused on refining the canopy cover – biomass relationship rather than improving the visual assessment.

9.2 Organizational structure for measurement, monitoring and reporting

Costa Rica's National Forest Monitoring System (NFMS), which generates information for the REDD+ Monitoring, Reporting, and Verification (MRV), has already been created[184]. The process started in 2015 when the National Center for Geospatial Information (CENIGA) initiated the designing process of the NFMS to cover all land uses and land use changes at the national level following IPCC's 2003 Good Practice Guidelines[185]. The NFMS is composed of two data collection mechanisms:

- The first is the Satellite Land Monitoring System (SLMS), which collects land use and land use change data. The agencies/institutions responsible for the SLMS are the National Meteorology Institute (IMN) and the REDD+ Secretariat, composed of the Fondo Nacional de Financiamiento Forestal (FONAFIFO) and the Sistema Nacional de Areas de Conservación (SINAC). The Instituto Metereológico Nacional

[183] Ortiz-Malavassi, E. (2017). Evaluación Visual Multitemporal (EVM) del Uso de la tierra, Cambio en el Uso de la Tierra y Cobertura en Costa Rica Zonas A y B Tarea 1: Estimación del área de cambio de uso de la tierra durante el periodo 2014-2015. Retrieved from https://drive.google.com/file/d/1GXdN43f-DNKelkM8y7gBLrKou-f7LI-G/view?usp=sharing
[184] https://redd.unfccc.int/files/4863_2_sistema_nacional_monitoreo_forestal_costa_rica.pdf
[185] Available at: https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

(IMN) is also responsible for Costa Rica's National GHG Inventory (INGEI) and the development and submission of Biennial Update Reports (BURs). Therefore, the collaboration between IMN and FONAFIFO is crucial to maintain consistency between the REDD+ reporting and the national GHG inventory. The IMN is also tasked with developing indicators that follow IPCC's Good Practice Guidelines and SIMOCUTE´s structure.

- The second data collection mechanism is the National Forest Inventory (NFI), which gathers forest field data to estimate and update the country's emission factors. This piece of the NFMS is led by the SINAC, which is also responsible for promoting sustainable forest management, logging permits, and control of illegal logging.

Other government entities involved in the REDD+ Program are: Ministerio de Ambiente y Energia (MINAE), which gives political support to the process; Colegio de Ingenieros Agrónimos (CIAgro), which supervises forestry professionals in charge of REDD+ Program implementation; Oficina Nacional Forestal (ONF) is the interlocutor between these government entities and the private sector; and Asociaciones de Desarrollo Integral Indigena (ADII), which supports indigenous groups. The inter-institutional REDD+ Board of Directors is responsible for issuing policies, making decisions, and resolving conflicts or grievances related to REDD+.

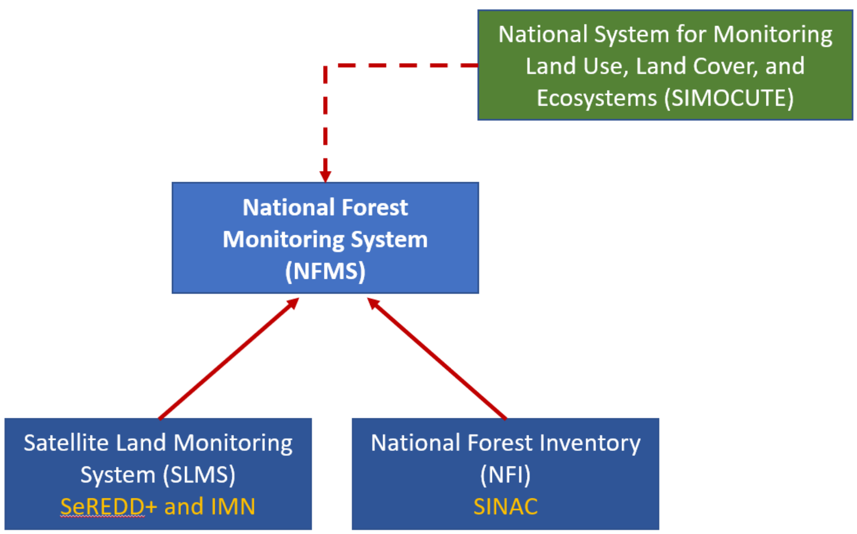

Figure 10. Organizational structure of the National Forest Monitoring System in Costa Rica.

The SIMOCUTE (National Monitoring System for Land Use, Land Use Cover, and Ecosystems) is the official platform for coordination, linkage, and institutional and sectoral integration of the Costa Rican State management and distribution of knowledge and information on land-use change and ecosystem monitoring. SIMOCUTE provides technical guidance for the monitoring, reporting, and verification (MRV) of land-use change in the AFOLU sector (agriculture, forests, and other land use). The technical working group of SIMOCUTE developed a monitoring methodology for the land-use change estimation area. The land-use change monitoring methodology is based on the visual interpretation of high-resolution imagery over 10,588 georeferenced systematic grid points. The procedure is designed to meet the country's forest monitoring needs by integrating all geospatial information produced in the country at the national, regional, and local levels. An early implementation phase of SIMOCUTE took place in 2017. Through this early implementation, Costa Rica conducted a first monitoring event and the first estimate of emission reductions as part of its ER-Program. SIMOCUTE is now a fully operational platform[186], and is designed to integrate the information of MRV system of emissions and removals of GHG from the AFOLU sector,

[186] Accessible at https://simocute.go.cr/

doing so in compliance with the national REDD+ program, the NAMAs, the national carbon trading system, and the progress of NDC implementation[187].

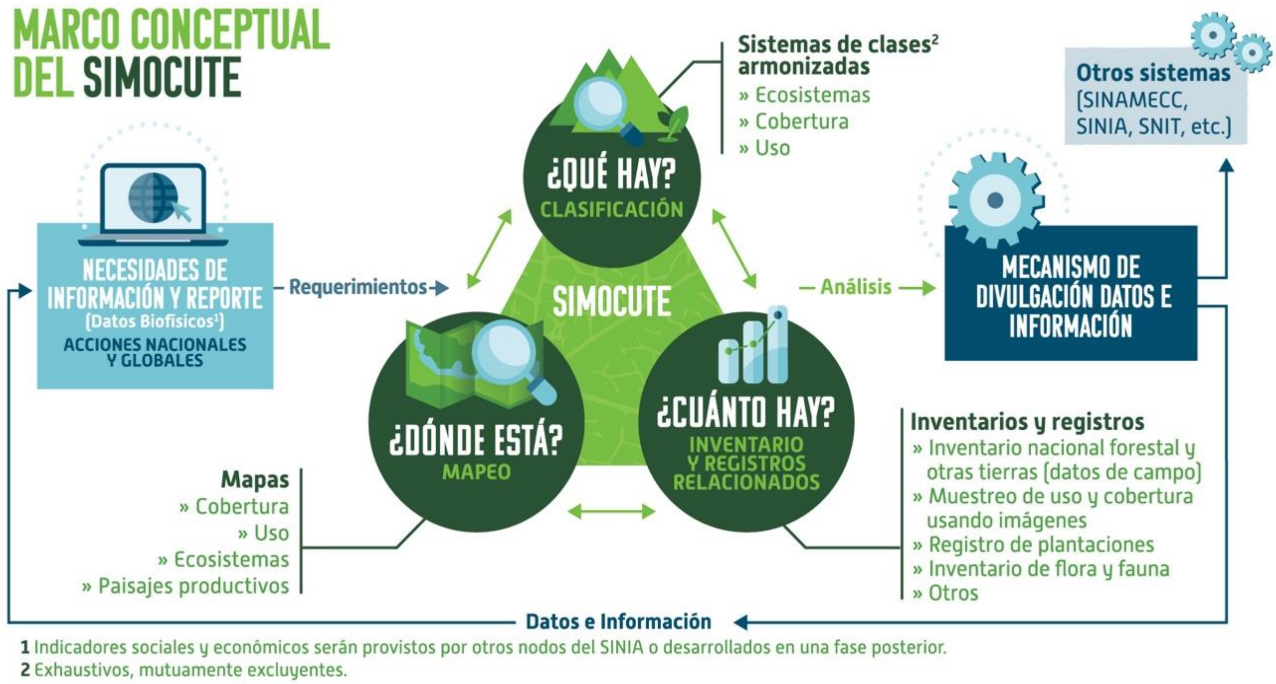

Figure 2. Conceptual Framework of Costa Rica's SIMOCUTE (National Monitoring System for Land Use, Land Use Cover, and Ecosystems). Source: MINAE 2017.

Costa Rica's National Forest Monitoring System (NFMS) was consolidated in 2019 and comprised a Terrestrial Satellite Monitoring System (SMST) and an INF. Through the SMST, national data on land-use changes are collected. The INF collects data to develop emission factors to estimate emissions and removals to be reported in the National Inventory of GHG for the AFOLU sector. The NFMS seats under a broader umbrella platform to coordinate all environmental information in the country, called SIMOCUTE (Sistema Nacional de Monitoreo de la Cobertura y el Uso de la Tierra y Ecosistemas in Spanish)[188].

REDD+ Secretariat counts with the support of the Costa Rica REDD-plus Result-Based Payments Project (RPB Project). This project will provide additional human resources and material inputs such as satellite imagery, hardware, software, and field monitoring equipment necessary for the Monitoring and reporting of REDD+ implementation. This activity will strengthen national capacities for REDD+ monitoring, reporting, and verification. Furthermore, this project will also provide support to meet the requirements of emerging market standards such as "The REDD+ Environmental Excellency Standard" (TREES) within the scope of the "Architecture for REDD+ Transactions" (ART) Program. RBP project will combine the market standards with Warsaw Framework for REDD+ results-based payments to maximize REDD+ financing for Costa Rica. Indeed, these standards can be made consistent with UNFCCC decisions for REDD+ while also including additional rules that reduce uncertainties and the risks of leakage and reversals. This activity will also support the verification of results by independent third parties. More specifically, this support will include

[187] www.sinac.go.cr/ceniga/?q=content/sistema-de-monitoreo-de-la-cobertura-y-uso-de-la-tierra-y-ecosistemas-simocute
[188] For further detail on the System for Measurement, Monitoring And Reporting Emissions And Removals occurring within the Monitoring Period, please See Section 2 of ER-Monitoring Report.

- Development and implementation of a diversified strategy for capturing REDD+ results-based payments from market and non-market sources based on international partnerships in line with the San Jose principles.
- Updating the FREL for a future submission, methodological improvements in response to technical assessment recommendations, and consolidating methodological consistency with the national GHG inventory and the NDC monitoring framework.
- Preparation of the second technical annex of REDD+
- Support for participation of Costa Rica in market mechanisms including the REDD+ Environmental Excellence Standard (TREES) of the Architecture for REDD+ transaction programme (ART).
- Support for validation and verification processes.

Role of communities in the forest monitoring system

The NFMS, conceived as an official information system, must adhere in its design and function to the current standards applicable to the processes of generating official information, which are regulated by several corresponding entities: The National Geographic Institute (IGN) and its national territorial information systems, the National Institute of Statistics and Census (INEC) regarding data usage, etc. That is why in principle, community participation is not expected in these systems, unless it becomes necessary at some points to fill gaps in the generation of data that may involve these forms of participation.

However, ER-Program envisions supporting measures lead to robust participation by communities and organizations in control actions related to forest resources. For example, SINAC efforts to strengthen the involvement of communities in firefighting through the so-called “Forest fire brigades” that are mainly composed of volunteers in zones with high susceptibility to these phenomena (see section 1.1). Also, SINAC efforts to strengthen the “Natural Resources Monitoring Committees” (COVIRENAS) and the activities of the Volunteers Association (ASVO), non-government entities that contribute through different activities coordinated with the appropriate government agencies, monitoring compliance with government legislation, in the first case, and in supporting the management of protected areas in the second.

SINAC is engaging different actors at the national level to promote participation in protecting and safeguarding natural resources. It is a mechanism that allows state institutions responsible for ensuring these resources to establish surveillance actions together with communities in compliance with the national legal framework. During 2019, SINAC held a series of training workshops to reactivate COVIRENAS, aimed at local actors interested in their formation, and training in the use of integrated environmental reporting process systems (its acronym in Spanish is SITADA), among others.

In addition to this, the Colegio de Ingenieros Agrónomos (Agronomists’ Association) as the governing entity of the “Certified Foresters” who are responsible for preparing and following-up on the management plans of the different modalities of payment for environmental services agreements, have an essential task in monitoring the beneficiaries´ compliance with their respective commitments or actions they have agreed to take with regard to conservation, restoration, reforestation or management. In that same sense, there are many local and regional forestry producer organizations that provide regency services to interested parties, and that have their capacities strengthened through PES. It is envisioned to strengthen these capacities through different lines of work incorporated in policies, actions and tasks of the PRE.

9.3 Relation and consistency with the National Forest Monitoring System

The approach for measurement, monitoring and reporting is consistent with standard technical procedures in the country. The approaches, methods, and protocols for estimating Activity Data (AD) and Emission Factor (EF) are the same as the existing National Forest Monitoring System (NFMS). The Instituto Metereológico Nacional (IMN) and the REDD+ Secretariat (SLMS responsible institutions) prepared the land use and land-use change maps for the monitoring period. SINAC collected the above-ground biomass used to estimate deforestation emissions with the implementation of the National Forest Inventory. The following QA/QC procedures, established in the NFMS for the Satelite Land Monitoring System (SLMS) and the National Forest Inventory (NFI), were used for the calculation:

- **Activity Data:** The QA/QC procedures applied during the calculation of AD for the reference and monitoring period are summarized in Tables 2, 3, 6, and 7, further information may be found in Agresta (2005)[189], Ortiz-Malavassi (2017)[190], and Aguilar (2020)[191].
- **Emission Factors:** The QA/QC procedures applied during the calculation of EF for deforestation and degradation are summarized in Tables 4 and 5, further information may be found in Ministerio de Ambiente y Energía (2015)[192], Rodriguez (2018)[193], Coto (2018)[194], and Obando (2019)[195].

The REDD+ Secretariat, in coordination with IMN, estimated the forest emissions for the monitoring period using the NFMS integration tools: i. tool to estimate emission and removals from deforestation and reforestation - FREL & MRV TOOL CR.xlsx[196], and ii. Tool for the estimate of emission and removals from degradation in permanent forest lands – Herramienta-degradacion.xlsx[197]. Finally, in coordination with IMN, the REDD+ Secretariat prepared the Emission Reduction report for the monitoring period 2018-2019 and provided technical support during the validation and verification process..

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[189] Agresta, Dimap, Universidad de Costa Rica, Universidad Politécnica de Madrid. 2015. Final Report: Generating a consistent historical time series of activity data from land use change for the development of Costa Rica's REDD plus reference level: Methodological Protocol. Report prepared for the Government of Costa Rica under the Carbon Fund of the Forest Carbon Partnership (FCPF). 44 pp. https://www.dropbox.com/s/ygjw6zq00a1qtbm/Informe_tecnico_feb_2015.pdf?dl=0

[190] Ortiz-Malavassi, E. (2017). Evaluación Visual Multitemporal (EVM) del Uso de la tierra, Cambio en el Uso de la Tierra y Cobertura en Costa Rica Zonas A y B Tarea 1: Estimación del área de cambio de uso de la tierra durante el periodo 2014-2015. Retrieved from https://drive.google.com/file/d/1GXdN43f-DNKelkM8y7gBLrKou-f7LI-G/view?usp=sharing

[191] Aguilar, L. (2020). Evaluación Visual Multitemporal para la determinación de la degradación forestal para los periodos 2014-2015-2017-2019 y determinación de datos de referencia para periodo 2017-2019. Tercer Informe. Retrieved from https://drive.google.com/file/d/1ERutZo6vNI6MXUCmlrky7wiaeOqOLMqh/view?usp=sharing

[192] Ministerio de Ambiente y Energía. (2015). Volumen 4 Marco conceptual y metodológico para la Inventario forestal nacional de Costa Rica. Retrieved from https://www.sirefor.go.cr/pdfs/Volumen4-MarcoC-Imprenta.pdf

[193] Rodríguez, J. (2018). INFORME FINAL DE CONSULTORÍA Estudio de parcelas temporales para estimar el stock de carbono en bosques intactos, degradados y altamente degradados en zona A. (Contrato N°020-2018-REDD). Retrieved from https://drive.google.com/file/d/1dSyL8Dldwym5VN1jXpnAbmPovUW3AiTu/view?usp=sharing

[194] Coto, O. (2018). INFORME FINAL DE CONSULTORÍA. Estudio de parcelas temporales para estimar el stock de carbono en bosques intactos, degradados y altamente degradados en zona B. (Contrato N° 019-2018-REDD). Retrieved from https://drive.google.com/file/d/1svYPJGEoBHpLn72sg4ejpf6uZkp6lllM/view?usp=sharing

[195] Obando, G. (2019). COORDINACIÓN GENERAL DE LA IMPLEMENTACIÓN DEL PLAN DE MEJORA DEL NIVEL DE REFERENCIA. Tercer Informe de Consultoría N ° 016-2018-REDD. Retrieved from https://drive.google.com/file/d/1MEHZ6dvQKY52X58UtlG02o4Uw9x1HV6v/view?usp=sharing

[196] The FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing

[197] Degradation tool can be accessed in the following link: https://drive.google.com/file/d/1GG3Z_QMWBKGNRdXnF_TdWP1ipH9dX5iH/view?usp=sharing

12 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

12.1 Identification and assessment of sources of uncertainty

An overview of the different sources of uncertainty can be found in Section 5, UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS of this monitoring report. Table 6 below provides the complete description of the analysis undertaken for the identification and assessment of sources of uncertainty of the Reference Level period.

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Activity Data					
Measurement	Systematic and random	**Land-use change areas (deforestation, reforestation and forest remaining forest areas)**: A unique and uniform methodology was used both for FREL / FRL and for the forest emission estimate to avoid that changes registered in the cartographic comparison of LULC maps were affected by the combination of different techniques and methods. This error represents the operator error during preparation and interpretation of LULCC maps. This error is reduced by the following QAQC procedures (see table 2 and 6). Quality control was first conducted during the download and image preparation phase by reviewing storage errors that affect the reading of the data, analyzing the image's metadata, and visually previewing the original image. The scenes of the reference period were analyzed by conducting the following image orthorectification procedures: i. Using control points, verify that the average square error never exceeds the pixel size of the image, ii. Visually inspect the image to ensure that there has been no defect in the orthorectification process (i.e., duplicate areas, pixel deformation, or geometry errors caused by errors in the digital terrain model), and iii. Using a regularly distributed grid, take checkpoints in each scene and perform geometric control of rectified images. For the scenes of monitoring period, it was not necessary to rectify the Landsat8 images supplied by the USGS. These images have a 1T processing level (Terrain corrected), a systematic geometric correction using ground control points for image registration with a WGS84 map projection. These also include correction of relief changes A radiometric normalization was applied to reduce the differences between the time-series images. The cloud	Low	Yes	No

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		and shadow masks in all images were then checked by visually comparing them with the original image in RGB or false color. These masks were then validated in a sample of 18 images by visual verification of a systematic grid of checkpoints. Further quality control measures were taken through an iterative process of land use classification, verification of classification, error detection, and review of areas and training points. Errors from the Random Forest classifier were reviewed, classes and training points that needed to be improved were identified, and classifications were visually checked against high resolution images. The final maps were prepared after mosaiced images were visually checked and information gaps and sensor failures on each of the dates in the series were identified. The final maps were subject to a quality assurance (QA) process that was provided by institutions of the country not used in the classification phase. These reviewers validated the final maps on three of the dates in the time series.			
Measurement	Systematic and random	**Permanent forest degradation and regeneration**: The same methodology was used to estimate degradation and regeneration in permanent forest lands. A Systematic Sampling (SYS) over the Level 1 Systematic Grid of 10,242 points of the Monitoring system of land-use change and ecosystems (SIMOCUTE) was used. The analysis of degradation was only performed on the area of forest remaining forest according to the land-use MCS 2017/18 map to avoid double-counting of baseline emissions between deforestation and forest degradation. This procedure avoided any measurements of degradation that were also accounted for under deforestation. In the assessment of degradation level in forests remaining forests, it was assumed that there was no uncertainty associated with the visual interpretation of sample areas because this procedure employed visual classification of canopy cover using high resolution imagery, as described above in tables 3 and 7. The following QA/QC procedures were applied during the interpretation of high-resolution imagery: i. **Consideration of spatial and temporal context**: The protocol includes a procedure for canopy cover change interpretation considering the spatial and temporal context (see section 1.6 in Aguilar, 2020).	Low	Yes	No

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		ii. **Reference order of the repositories of images**: The analyst gave priority to high-resolution images in Google Earth. In the second instance, on the Planet images available for the monitoring period. In case there are no high-resolution images for any sampling points, lower-resolution images available in the Collect Earth Desktop tool were used, as long as the monitoring period images are equal or better quality than the 2017 assessment. iii. **Data registry forms**: The canopy cover change information was recorded in standard Collect Earth Desktop forms (see section 1.7 in Aguilar, 2020). iv. **Training**: The supervisor trained the interpreters before starting the interpretation of plots to calibrate and leave clear procedures to collect the most accurate information possible. v. **Supervision of interpreters ("Hot Checks"):** The supervisor opened remote sessions between the coordinator and the interpreter (due to the Covid); to oversee the evaluation process without intervening. The coordinator presented the results in periodic sessions with all interpreters to improve the group of interpreters' criteria. The supervisor resolved the consultations of the interpreters online. vi. **Checking of interpretations by the supervisor, without interpreters' presence ("Cold Checks"):** The supervisor reviewed at least 5% of the parcels evaluated. The points that do not coincide were reviewed together by the supervisor and all the interpreters. vii. **Checking of interpreters' consistency ("Blind Checks"):** The analysts performed this procedure at the end of interpreting all the sampling plots. Each analyst evaluated at least 5% of the assessed plots by other interpreters, e.g., Interpreter 1 reviewed interpreters 2 and 3. The minimum level of consistency between evaluators was 90%. If not complying with the standard, the interpreter team should review the work until reaching the 90% threshold. viii. **Consistency between reference and monitoring period data**: The analyst reviewed the consistency of 2018 canopy cover data with			

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		the 2016 evaluation performed by Ortiz-Malavassi (2017). ix. **Treatment of plots with forest cover less than 30%:** The analyst made the degradation analysis over the systematic grid points that falls on permanent forest lands during 1998-2011 in REDD time series maps. Thus, the 4,377 points of the original sampling implemented by Ortiz-Malavassi (2017) were re-visited in 2016, 2018, and 2020 evaluations. During the review of these points, some of them passed to non-forest conditions due to the loss of coverage and non-compliance with the minimum forest definition area (30% of canopy cover). Some of these points may have been declared deforestation or being part of the omission error in the land-use change's permanent forests for the periods 2012-13, 2014-15, 2016-17, 2018-19. Finally, uncertainty of changes in canopy cover to identify areas of degradation and forest enhancement from reference and monitoring periods vary depending on the forest type and the conversion class. It is based on the sampling error.			
Representativeness	Systematic	**Land-use change areas (deforestation, reforestation and forest remaining forest areas)**: Land-use change areas (deforestation, reforestation and forest remaining forest areas): To prepare the LULCC maps for reference and monitoring periods, four generations of LANDSAT satellites were used: Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM +, Landsat 8 OLI / TIRS. Scenes were selected from June (Year 1) to June (Year 2) for the period under monitoring. Monitoring occurs every two years, and the territorial forest area covered includes the country's continental territory but excludes the Coco Island due to its exclusion from anthropogenic intervention. To ensure the representativeness of the LULCC maps, the Random Forest methodology is used for the reference and monitoring periods to train a forest classifier and then classify imagery. To train the forest classifier, regions of different land cover classes were digitized using (1) a systematic grid of 10,000 points from Rapideye images developed by SINAC, (2) high-resolution images from Rapideye, and (3) current and historical Google Earth images. This base data was then combined with 20 predictor variables to adjust the forest classifier models. To minimize the error (i.e. uncertainty) in these classifier models, the Random Forest R package generates an error	Low	Yes	No

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
		and confusion matrix which allows for an initial quality control check based on a subset of checkpoints. To further minimize uncertainty, the random forest classifier was iteratively improved by analysts using the error and confusion matrix generated by the classifier, which identifies classes that need improved training data or predictor variables. Once the classifiers were trained, they were applied to all images to assess land use land cover for the given two-year period. The resulting land use land cover maps then underwent post processing to further reduce uncertainty in classification, through visual comparison of classified maps and high-resolution imagery, analysts performed manual edition of the time-series classification aimed at decreasing high classification errors. Analysts also performed visual verification of the country's main deforestation and reforestation areas to detect any classification errors to ensure an accurate assessment of land use-change. **Permanent forest degradation and regeneration**: High-resolution imagery used to estimate degradation and regeneration were selected from June to June for the year under monitoring.			
Sampling	Random	**Land-use change areas (deforestation, reforestation and forest remaining forest areas)**: Uncertainties associated to AD are due to the production process of land use maps. The uncertainties of the AD for land use change activities (deforestation and reforestation) and forest remaining forest activities (degradation and enhancements in forest lands) come from the uncertainties associated with the process creating land use change maps from which the activity data are obtained. The accuracy assessment of the land-use changes map MCS 2001/02, MCS 2011/12, MCS 2017/18, and MCS 2019/20 was done following Olofsson et al.'s (2014)[198] guidelines. Due to a large number of land-use change transitions, they were aggregated into four categories: Deforestation (forest to non-forest), new forests (non-forest to forest), stable forest (forest remaining forest), and stable non-forest (non-forest to non-forest). For further detail of the accuracy assessment for the reference and monitoring periods please see the uncertainty section in tables 3 and 6.	Low	Yes	Yes

[198] Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148, 42-57.

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
	Random	**Permanent forest degradation and regeneration**: The same methodology was used to estimate degradation and regeneration in permanent forest lands for reference and monitoring period. A Systematic Sampling (SYS) over the Level 1 Systematic Grid of 10,242 points of the Monitoring system of land-use change and ecosystems (SIMOCUTE) was used. Uncertainty of changes in canopy cover to identify areas of degradation and forest enhancement for reference and monitoring vary depending on the forest type and the conversion class. It is based on the sampling error.	Low	No	No
Extrapolation	NA	This source of uncertainty is not applicable. Costa Rica generates estimates of deforestation, regeneration, and permanent forest lands per forest type, where the total annual areas are the sum of each forest type for a given year.	NA	NA	NA
Approach 3	NA	This source of uncertainty is not applicable. Activity data were estimated conducting tracking of lands or IPCC Approach 3 for reference and monitoring periods.	NA	NA	NA
Emission Factor					
DBH measurement	Systematic and Random	Extensive quality control procedures were implemented prior to the start of field work during estimation of AGB in the National Forest Inventory and Canopy cover and biomass relationship with additional temporal sampling plots. Field crews were organized by region. Each field crew was trained and provided with manuals to assist with identification, collection, transport, and processing of botanical samples. A terms of reference document was also provided which explained specific roles and responsibilities of each crew member. Finally, an Excel template was created to control the quality of data collection. Quality assurance measures were then taken as supervisors visited field sites to oversee the field crews and take photographic records of each field plot (please see tables 4 and 5). The quality of forest inventory data then underwent an evaluation by an independent crew that visits and remeasures 10% of the plots established in the NFI and 5% of the 100 additional plots. Thanks to these QA/QC procedures implemented before, during, and after the field campaigns the potential biases in the measurement of DBH, H, and plot delineation have been minimized. The random error associated with the measurement of these parameters has therefore been considered to be low, and thus this source of error will not be propagated.	Low	Yes	No
H measurement					
Plot delineation					

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Wood density estimation	Systematic and Random	The wood density values were obtained directly from specialized publications (Biomass estimation tool developed by SINAC, IPCC 2003[199]; Myers 2013[200]; Tree Functional Attributes and Ecological Database, 2018[201]). High-skilled specialists conducted the tree identification following specific protocols to mitigate the error when the wood density value was assigned to each tree.	Low	Yes	No
Biomass allometric model	Systematic and Random	The biomass was calculated using Chave et al. (2005) for NFI inventory data, and Chave et al. (2014) for the 100 additional AGB plots. The propagation of error through MC simulation did not include this source of uncertainty due to the complexity of calculation, the lack of bias (given errors from allometric equations are not systematic), and the agreement of experts in the fields and of standards (cf. ART) that it is reasonable to exclude this form of error.	Low	No	No
Sampling	Random	Sampling error is the statistical variance of the estimate of aboveground biomass, dead wood or litter. This source of error is random and is considered to be high and it has been propagated. In Costa Rica, sampling error was identified for aboveground biomass values in primary forests in its National Forest Inventory. In secondary forests and in other carbon pools, sampling error of biomass values was estimated from scientific literature. Sampling error was also identified when estimating the ratio between canopy cover and aboveground biomass based on plot data.	High	No	Yes
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	Systematic and Random	Below ground biomass (BGB) is derived directly from Cairns et al., (1997)[202]. The carbon fraction employed was PCC's default value (0.47). The propagation of error through MC simulation did not include either the uncertainty of the root-shoots rations or carbon fraction.	Low	No	No
Representativ eness	NA	This source of uncertainty is not applicable. Costa Rica generates estimates of carbon stocks per forest type.	NA	NA	NA
Integration					
Model	Systematic	Manuals have been prepared for the correct use of FREL and Degradation tools[203], to avoid errors during the process of data preparation.	Low	Yes	No

[199] IPCC. 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry. Intergovernmental Panel on Climate Change (IPCC). Edited by Jim Penman, J.; Gytarsky, M.; Hiraishi, T.; Krug, T.; Kruger, D.; Pipatti, R.; Buendia, L.; Miwa, K.; Ngara, T.; Tanabe K.; Wagner, F. IPCC National Greenhouse Gas Inventories Programme. Published by the Institute for Global Environmental Strategies (IGES) for the IPCC. 583 p.

[200] Myers, R. 2013. Fenología y crecimiento de Raphia taedigera (Arecaceae) en humedales del noreste de Costa Rica. En:Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744) Vol. 61 (Suppl. 1): 35-45

[201] Tree Functional Attributes and Ecological Database. (2018). Wood Density. Recuperado el 10 de 12 de 2018, de http://db.worldagroforestry.org/.

[202] Cairns M.A., Brown S., Helmer E.H., and Baumgardner G.A. (1997). Root biomass allocation in the world's upland forests. Oecologia 111:1-11.

[203] The manual of FREL Tool can be accessed in the following link: https://drive.google.com/file/d/1INuL5Jld7nlKVsAf7mRsEepm2n8WRVpT/view?usp=sharing

Sources of uncertainty	Systematic and/or random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Integration	Systematic	The Emission factors were calculated for each forest type according to AGB sampling plots' location to assure the comparability between transition classes of the Activity Data and those of the Emission Factors. This source of uncertainty is considered in the sampling error of the AGB inventory.	Low	No	No

12.2 Quantification of uncertainty in Reference Level Setting

Parameters and assumptions used in the Monte Carlo method

Parameter included in the model	Parameter values	Range: Margin of error (Half the 90% confidence interval)	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Area (hectares) of deforestation	426,148 ha from 1998-2011	120,871	Sampling error	Truncated normal	Minimum value assumed to be 0
Area (hectares) of forests remaining forests	2,233,119 ha from 1998-2011	79,861	Sampling error	Truncated normal	Minimum value assumed to be 0
Area (hectares) of new forests	10,646,850 ha from 1998-2011	3,274,836	Sampling error	Truncated normal	Minimum value assumed to be 0
Change in percent canopy cover in degraded and regenerated forests	Varies depending on the level of degradation and regeneration	Varies depending on the level of degradation and regeneration	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for very moist and rain forests – primary (t CO_2e)	313.69	63.54	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for moist forests - primary (t CO_2e)	203.99	41.86	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for dry forests – primary (t CO_2e)	199.19	302.80	Sampling error	Truncated normal	Minimum value assumed to be 0

Parameter included in the model	Parameter values	Range: Margin of error (Half the 90% confidence interval)	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Aboveground biomass for mangroves – primary (t CO_2e)	253.74	31.83	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for palm forest – primary (t CO_2e)	229.81	25.03	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for secondary forests (t CO_2e)	Varies depending on age (1-400 years) and forest type	Varies depending on age (1-400 years) and forest type	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for annual cropland (t CO_2e)	83.57	9.69	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for permanent cropland (t CO_2e)	Varies depending on age (1-400 years)	Varies depending on age (1-400 years)	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass for paramos (t CO_2e)	126.87	2.16	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for very moist and rain forests – primary (t CO_2e)	71.97	14.58	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for moist forests - primary (t CO_2e)	48.32	9.92	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for dry forests – primary (t CO_2e)	47.27	71.86	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for mangroves – primary (t CO_2e)	53.96	7.42	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for palm forest – primary (t CO_2e)	53.96	5.88	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for	Varies depending on	Varies depending on	Sampling error	Truncated normal	Minimum value assumed to be 0

Parameter included in the model	Parameter values	Range: Margin of error (Half the 90% confidence interval)	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
secondary forests (t CO_2e)	age (1-400 years) and forest type	age (1-400 years) and forest type			
Belowground biomass for annual cropland (t CO_2e)	21.16	9.69	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for permanent cropland (t CO_2e)	Varies depending on age (1-400 years)	Varies depending on age (1-400 years)	Sampling error	Truncated normal	Minimum value assumed to be 0
Belowground biomass for paramos (t CO_2e)	31.13	2.16	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for very moist and rain forests – primary (t CO_2e)	49.5	8.75	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for moist forests - primary (t CO_2e)	48.27	23.75	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for dry forests – primary	56.47	21.92	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for mangroves – primary (t CO_2e)	6.95	2.05	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for palm forest – primary (t CO_2e)	5.97	7.02	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for secondary forests (t CO_2e)	Varies depending on age (1-400 years) and forest type	Varies depending on age (1-400 years) and forest type	Sampling error	Truncated normal	Minimum value assumed to be 0
Deadwood for grassland (t CO_2e)	8.28	6.29	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for very moist and rain forests – primary (t CO_2e)	10.05	0.94	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for moist forests - primary (t CO_2e)	8.01	1.04	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for dry forests – primary (t CO_2e)	22.73	0.61	Sampling error	Truncated normal	Minimum value assumed to be 0

Parameter included in the model	Parameter values	Range: Margin of error (Half the 90% confidence interval)	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Litter for mangroves – primary (t CO_2e)	0.97	0.24	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for palm forest – primary (t CO_2e)	0.96	1.13	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for secondary forests (t CO_2e)	Varies depending on age (1-400 years) and forest type	Varies depending on age (1-400 years) and forest type	Sampling error	Truncated normal	Minimum value assumed to be 0
Litter for permanent cropland (t CO_2e)	Varies depending on age (1-400 years)	Varies depending on age (1-400 years)	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in very moist and rain forests (t CO_2e)	5.03	0.81	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in moist forests (t CO_2e)	3.86	0.84	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in dry forests (t CO_2e)	3.47	1.98	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in mangroves (t CO_2e)	3.19	1.01	Sampling error	Truncated normal	Minimum value assumed to be 0
Aboveground biomass-canopy cover ratio in palm forests (t CO_2e)	4.26	1.59	Sampling error	Truncated normal	Minimum value assumed to be 0

Quantification of the uncertainty of the estimate of the Reference level

		Deforestation	Forest degradation	Enhancement of carbon stocks
A	**Median**	86,209,025	19,016,994	-71,814,596
B	**Upper bound 90% CI** (Percentile 0.95)	128,233,984	26,926,056	-67,932,082
C	**Lower bound 90% CI** (Percentile 0.05)	49,450,792	12,501,392	-75,770,915
D	**Half Width Confidence Interval at 90% (B – C / 2)**	39,391,596	7,212,332	3,919,416
E	**Relative margin (D / A)**	46%	38%	5%
F	**Uncertainty discount**	8%	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
2.4	May 2022	• Page 1 and section 8 have been adjusted to reflect the dentition of Total ERs
2.3	December 2021	• Section 5.2 was adjusted to allow the reporting of the uncertainty estimates for both the reporting period and the crediting period. • Section 8 has been adjusted to clarify that countries can also report ERs jointly and not only in separate calendar years.
2.2	August 2021	• Cross-references have been corrected • Information about the start date of the crediting period has been requested in annex 4.
2.1	November 2020	Aspects on uncertainty analysis were revised based on the guidelines on uncertainty analysis.
2	June 2020	Version approved virtually by Carbon Fund Participants. Changes made: • Update to consider the changes made to the Methodological Framework (Version 3.0) and Buffer Guidelines (Version 2.0) • Update to consider the changes made to the Validation and Verification Guidelines
1	January 2019	The initial version approved by Carbon Fund Participants during a three-week non-objection period.