



**Forest Carbon Partnership Facility (FCPF)  
Carbon Fund**

**ER Monitoring Report (ER-MR)**

<b>Forest Carbon Partnership Facility (FCPF) Carbon Fund</b>	
<b>ER Monitoring Report (ER-MR)</b>	
<b>ER Program Name and Country:</b>	Costa Rica
<b>Reporting Period covered in this report:</b>	<i>01-01-2020 to 31-12-2021</i>
<b>Number of FCPF ERs:</b>	3,333,103 t CO <sub>2</sub> e*
<b>Quantity of ERs allocated to the Uncertainty Buffer:</b>	505,016 t CO <sub>2</sub> e
<b>Quantity of ERs to allocated to the Reversal Buffer:</b>	185,172 t CO <sub>2</sub> e
<b>Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:</b>	185,172 t CO <sub>2</sub> e
<b>Date of Submission:</b>	<i>30-06-2023</i>
<b>Version</b>	1.0

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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](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.



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## Acronyms List

**AC:** Conservation Areas  
**ACC:** Central Conservation Area  
**AD:** Activity data  
**ADII:** Asociaciones de Desarrollo Integral Indígena (Associations for Integral Indigenous Development)  
**AFOLU:** Agriculture, Forests, and Other Land Use  
**ASP:** Protected Wilderness Areas  
**ASVO:** Volunteers Association  
**CATIE:** Tropical Agricultural Research and Higher Education Center  
**CENIGA:** National Geo-environmental Information Center  
**CIAgro:** Colegio de Ingenieros Agrónomos (College of Agricultural Engineers)  
**CIRAD:** Center for International Cooperation in Agricultural Research for Development  
**CONAC:** The National Council of Conservation Areas  
**COVIRENA:** Natural Resources Surveillance Committees  
**CREF:** Contract for the Reduction of Forest Emissions  
**DCC:** Climate Change Directorate  
**EF:** Emission Factors  
**ER:** Emission Reduction  
**ER-MR:** Emission Reduction-Monitoring Report  
**ERPA:** The Emissions Reduction Purchase Agreements  
**ER-PD:** Emission Reduction Program Document  
**FCPF:** Forest Carbon Partnership Facility  
**FONAFIFO:** National Fund for Forest Financing  
**FREL/FRL:** Forest reference emission level/forest reference level  
**IGN:** National Geographic Institute  
**IMN:** National Meteorology Institute  
**INEC:** Institute of Statistics and Census  
**INF-CR:** Costa Rica's Nacional Forest Inventory  
**INGEI:** National GHG Inventory  
**IPCC:** Intergovernmental Panel on Climate Change  
**LULCC:** Land Use Land Cover Change  
**LULUCF:** Land Use, Land-Use Change and Forestry  
**MAG:** Ministry of Agriculture and Livestock  
**MCS:** Land Cover Maps  
**MINAE:** Ministry of Environment and Energy  
**MRV:** Monitoring, Reporting, and Verification  
**NFMS:** National Forest Monitoring System  
**ONF:** Oficina Nacional Forestal (National Forest Office)  
**PES:** Payment for Environmental Services  
**PGM:** General Management Plans  
**PNCB:** National Biological Corridors Program  
**PNE:** State Natural Heritage Lands  
**PPC:** Prevention, Protection, and Control Plans  
**PRE:** Emission Reduction Program  
**PSA:** Environmental Services Payment Program  
**RMSE:** Root Mean Square Error  
**SAF:** Agroforestry Systems  
**SATIF:** Forest Fire Early Warning System  
**SEPLASA:** Secretariat for Sector Planning for the Environment, Energy, Seas and Territorial Planning  
**SICAF:** System for the Control of Forest Harvesting

**SIMOCUTE:** National Monitoring System for Land Use, Land Use Cover, and Ecosystems  
**SINAC:** Sistema Nacional de Areas de Conservación (National System of Conservation Areas)  
**SINAMECC:** National System of Climate Change Metrics of Costa Rica  
**SIPLAMA:** System of Management Plans  
**SITADA:** Integrated Environmental Complaint Processing System  
**SLMP:** Satellite Land Monitoring Protocol  
**SLMS:** Satellite Land Monitoring System  
**SPMH-ACLAC:** Strategy and Action Plan for the Participatory Strengthening of the World Heritage Site of La Amistad Caribe  
**TREES:** The REDD+ Environmental Excellency Standard  
**UMP:** Primary Sampling Unit  
**UNFCCC:** United Nations Framework Convention on Climate Change  
**USGS:** United States Geological Survey

# 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 critical 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 2020-2021 period<sup>1</sup> (for further detail, see Annex 1).

**ACTION 1.1. Strengthen the operation and financing of SINAC's Forest Fires Management Strategy inside and outside Protected Conservation Areas:** SINAC is currently focused on implementing the National Fire Management Strategy 2012-2021. The aim is to achieve an integrated fire management approach involving stakeholders such as local and national government institutions, NGOs, the private sector, and civil society. As a result of this implementation, the following activities have been made:

- Development of the Forest Fire Early Warning System (SATIF)<sup>2</sup>, which evaluates factors that could lead to a fire and predicts its potential behavior at a national level. The system was created using the Forest Carbon Cooperative Fund (FCPF) readiness funds, SINAC's budget, and administrative support from the National Fund for Forest Financing (FONAFIFO) and the REDD+ Secretariat. SATIF's official launch took place in February 2020.
- Every year, SINAC organizes national, regional, and local forest fire management campaigns. However, the COVID-19 pandemic and Ministry of Health regulations have impacted the campaign. To comply with safety regulations, the focus shifted to press conferences, broadcasting on national and regional TV channels, radio programs, recording and editing a play, and social media posts. Additionally, the institutional budget was reduced by 50% since 2020, forcing SINAC to rely on external resources provided by the Canada Fund<sup>3</sup> for local initiatives to carry out the Fire Prevention Campaign.
- SINAC promotes and coordinates volunteer forest fire brigades, including training for officials and volunteers. In 2020 and 2021, 27 training workshops were held, with 475 firefighters and forest firefighters (341 men and 134 women) participating. Despite the pandemic<sup>4</sup>, 5 workshops were conducted in 2020, and 22 were held until November 15, 2021. SINAC has established the National Guide for the Training and Certification of Personnel in Comprehensive Fire Management, which sets the standard for fire management training and education<sup>5</sup>. Finally, SINAC allocated a budget for equipment to be provided for both institutional and voluntary forest firefighters. Additionally, funds have been allocated for hiring reinforcement brigades and maintaining firewalls in high-incidence areas that have been identified<sup>6</sup>.

**ACTION 1.2: Strengthen the operation and financing of SINAC's Illegal Logging Control Strategy:** SINAC is responsible for preventing illegal logging and overseeing sustainable forest management activities. SINAC implemented two online systems to grant logging permits on private land: the System of Management Plans (SIPLAMA<sup>7</sup>) for logging permits on forest lands and the Information System for the Control of Forest Harvesting (SICAF<sup>8</sup>) for logging permits on pasture and agricultural lands. During this reporting period, SINAC made improvements to SICAF based on suggestions from its

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<sup>1</sup> See Policies, actions, and activities included in the ER-P and the National REDD+ Strategy, in Table 4.3.1 of the Emission Reduction Program Document.

<sup>2</sup> The SATIF is hosted on the server of the National Meteorological Institute (<https://www.imn.ac.cr/alerta>) and the geographic viewer can be accessed at the following link <https://gestion.incendiosforestales.cr/mapa/mapa>.

<sup>3</sup> Canada Fund for Local Initiatives – Costa Rica, Nicaragua and Honduras <https://www.international.gc.ca/world-monde/funding-financement/cfli-fcil/2023/costa-rica-nicaragua-honduras.aspx?lang=spa>

<sup>4</sup> During the COVID-19 pandemic, MINAE created a COVID-19 protocol to guide activities and prevent the spread of the virus. The protocol mandates a 1.80 distance between participants, the mandatory use of masks, frequent hand washing and use of alcohol, dining in open spaces with social distancing, and limiting capacity to less than 30%.

<sup>5</sup> [https://www.acguanacaste.ac.cr/images/imagenes-noticias/proteccion/guia\\_nacional\\_de\\_capacitacion\\_cr.pdf](https://www.acguanacaste.ac.cr/images/imagenes-noticias/proteccion/guia_nacional_de_capacitacion_cr.pdf)

<sup>6</sup> The practice of maintaining firebreaks is not synonymous with the removal of forested areas. Rather, it entails the strategic clearing of vegetation or land that plays a critical role in mitigating the potential for forest fires.

<sup>7</sup> SIPLAMA [http://siplama.sirefor.go.cr/zf\\_GestionSolicitudes/Index/paginadebienvenida](http://siplama.sirefor.go.cr/zf_GestionSolicitudes/Index/paginadebienvenida)

<sup>8</sup> SICAF <https://sicaf.addax.cc>



users. This included maintenance and adjustments for better performance and adding new modules, such as those for harvesting fallen wood.

Patrols and control operations were conducted, particularly during important dates like Easter and Christmas, when there is a higher risk of illegal activities such as forest burning and illegal logging. Complaints were also addressed, with forestry issues being the most common cause for concern.

SINAC continues implementing the Natural Resources Surveillance Committees (COVIRENA), engaging different actors at the national level in promoting participation in the protection and safeguarding of natural resources in compliance with the national legal framework. During this reporting period, SINAC trained COVIRENA's volunteers to use the Integrated Environmental Complaint Processing System (SITADA<sup>9</sup>), and 24 groups were accredited and prepared. Training in using this tool was also given to SINAC officers.

**ACTION 1.5: Contribute to the consolidation of SINAC's Protected Areas System:** SINAC has produced guidelines for establishing, expanding, modifying, and managing Protected Wilderness Areas. These documents serve as a reference for creating the General Management Plan and provide methodological guidance for developing Prevention, Protection, and Control Plans (PPC), sustainable tourism, waste management, research, natural resource management, and ecological integrity. Based on these instruments, 12 general management plans (PGM) were approved, which were: Dr. Archie Carr and Isla San Lucas National Wildlife Refuges, Chayote Protection Zone, Río Toro, and Abangares Protection Zones, Alberto Biological Reserve Manuel Brenes, Cerro Vueltas Biological Reserve, National Parks: Tapantí, Braulio Carrillo, Los Quetzales, La Cangreja, and the Guayabo National Monument.

In 2020, SINAC started implementing the "Strategy and Action Plan for the Participatory Strengthening of the World Heritage Site of La Amistad Caribe (SPMH-ACLAC)." This plan aimed to diagnose the interrelationships among populations in the conservation area, particularly in seven out of eight indigenous territories (two Bribri and five Cabécar). The plan considered the dynamics of the territories, their models of coexistence, care, and use of nature, and their culture of conservation to establish a governance structure. As a result, 12 additional general management plans (PGM) were approved.

SINAC launched in 2015 a tool for evaluating the effectiveness of managing Wilderness Protected Areas (ASP)<sup>10</sup>. SINAC implemented the use of this tool since 2016 to the present. This tool started with REDD+ preparation resources and helped with adaptive management. It also assisted in allocating resources more efficiently, promoting transparency and accountability to stakeholders, and involving strategic allies to promote ASPs. The tool fostered a learning culture within the organization. The application of this tool has resulted in obtaining reports on the management results of ASPs and Conservation Areas (CA), as well as their improvement plans. Workshops or work sessions were conducted in each evaluated ASPs in Costa Rica to develop the management effectiveness evaluation process. The ASP Administrators and their work teams attended these meetings to apply the corresponding instrument. In some cases, representatives of local actors who contribute to biodiversity conservation in these areas also participated.

In addition to managing ASP categories, SINAC also supports a second conservation strategy called Biological Corridors (CB), which is promoted through the National Biological Corridors Program (PNCB) and encourages participation.

In 2019, the creation of the ASP-PNE, which aims to protect natural heritage areas, began with the help of the REDD+ Readiness funds. In 2020, the design process for the ASP-PNE was also initiated. The National Council of Conservation Areas (CONAC) approved this chapter through agreement No. 11 of the Ordinary Session No. 07-2021 CONAC<sup>11</sup>. The ASP-PNE chapter will be included in the updated National Forestry Development Plan for the new execution period.

**ACTION 1.4: Develop a strategy to integrate public lands to the State Natural Heritage:** SINAC developed a Land Tenure Management System for State Natural Heritage Lands in protected wild areas with REDD+ readiness funds in 2019. However, the tool's computer structure and work guides were not fully adjusted until 2020. This system is a web platform for SINAC officers, which manages certifications, visas, purchases, donations, and vacant land registrations, with their respective review processes. This platform operates with high-security standards. The tool's implementation started with a pilot in the Central Conservation Area (ACC) in 2021. The system has a geospatial module for SINAC

<sup>9</sup> SITADA <https://www.sitada.go.cr/denunciaspublico/>

<sup>10</sup> Tool for evaluating the management effectiveness of Protected Wilderness Areas <https://www.sinac.go.cr/ES/docu/ASP/Herramienta-Evaluacion-Efectividad-de-Manejo.pdf>

<sup>11</sup> Oficio de aprobación del SINAC-CONAC-SA-155-07-2021 con fecha del 15 de julio de 2021 <https://www.sinac.go.cr/ES/transprncia/Acuerdos%20CONAC%202021/ACUERDOS%20SO%20N%C2%B0%207-2021.pdf>

officers and another for the public. These modules contain layers such as the State Natural Heritage Lands (PNE), Conservation Areas (AC), Protected Wilderness Areas (ASP), forest types, and wetlands, among others. The layers and tools for SINAC officials are more detailed than those available to the public and help to manage ASPs better. The information in this module may be helpful for ASP monitoring, research, and education purposes.

**ACTION 5.2: Improve competitiveness of forestry and agroforestry financing mechanisms, also in relation to other land uses:** FONAFIFO's Board of Directors has made significant decisions regarding forest conservation, including increasing the funds allocated towards conservation actions in 2020-2021. They are also considering implementing the Forest Emission Reduction Contracts scheme, which aims to involve more forest owners nationwide. Additionally, FONAFIFO has published a new manual for procedures to improve financial mechanisms within the Environmental Services Payment Program (PSA 2020)<sup>12</sup>. The manual includes several changes, such as updates to legislation, computer platforms, access to information, implementation of technological tools, new PSA sub-activities, and adjustments in processes and procedures. These changes highlight the improvements made to management in technical and legal issues.

**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 eliminates risks to curb deforestation and forest degradation. FONAFIFO continued promoting forest protection; it had a significant boost to increase coverage in 2020 and 2021. A FONAFIFO Board agreement raised PES funds for forest protection. Most indigenous peoples participated through information, pre-consultation, and consultation mechanisms. Also, REDD governance operated satisfactorily.

**ACTION 6. Effectiveness of the organizational arrangements and involvement of partner agencies:** In May 2021, the Government officialized<sup>13</sup> 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 change and ecosystem monitoring.

The executive decree No. 42886-MINAE-MAG-JP<sup>14</sup> was published in March 2021, establishing the SIMOCUTE monitoring system under the responsibility of the Ministry of Environment and Energy (MINAE), in coordination with the Ministry of Agriculture and Livestock (MAG) and the Ministry of Justice and Peace (MJP). SIMOCUTE is led by the National Geo-environmental Information Center (CENIGA) of MINAE and is a part of Costa Rica's efforts to promote the use of information technologies and spatially explicit data. This important achievement marks a significant milestone in the development of the system.

SIMOCUTE is linked to critical national commitments, with Goal 42 of the National Biodiversity Strategy, the Monitoring of the National Decarbonization Plan for the Agriculture, Forestry, and Other Land Use sectors, and the commitments of the Support Program for the National Plan of Decarbonization. It is also considered one of the mechanisms for implementing the Agro-Environment Agenda and the Urban Environment Agenda.

Regarding strengthening technical capacities, training and projects have been carried out in collaboration with institutions such as the Center for International Cooperation in Agricultural Research for Development (CIRAD)<sup>15</sup> and the Tropical Agricultural Research and Higher Education Center (CATIE). In addition, work has been done on the development of a technological platform that will allow better monitoring and analysis of the coverage and use of land and ecosystems in Costa Rica.

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<sup>12</sup> New PSA 2020 procedures manual <https://onfcr.org/wp-content/uploads/Manual-de-Procedimientos-PSA-2020-14-abril-2020.pdf>

<sup>13</sup> Decreto Ejecutivo N° 42886-MINAE-MAG-JP available at [https://simocute.go.cr/wp-content/uploads/2021/05/LYD\\_Decreto-Firmas-No.https://simocute.go.cr/wp-content/uploads/2021/05/LYD\\_Decreto-Firmas-No.-42886-MINAE-MAG-JP.pdf42886-MINAE-MAG-JP.pdf](https://simocute.go.cr/wp-content/uploads/2021/05/LYD_Decreto-Firmas-No.https://simocute.go.cr/wp-content/uploads/2021/05/LYD_Decreto-Firmas-No.-42886-MINAE-MAG-JP.pdf42886-MINAE-MAG-JP.pdf)

<sup>14</sup> 42886-MINAE-MAG-JP

[http://www.pgrweb.go.cr/scii/Busqueda/Normativa/Normas/nrm\\_texto\\_completo.aspx?param1=NRTC&nValor1=1&nValor2=94331&nValor3=125551&strTipM=TC](http://www.pgrweb.go.cr/scii/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=94331&nValor3=125551&strTipM=TC)

<sup>15</sup> <https://www.cirad.fr/en>

**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.

As of 2020, there have been improvements in regeneration management by implementing a new PSA modality called Mixed Systems<sup>16</sup>. This modality aims to support the inclusion of micro-producers and producers in various forestry activities, including regeneration, forest protection, and Agroforestry Systems (SAF) on farms smaller than 15 hectares. By using this mechanism, the transaction cost for farm owners is reduced, which encourages their participation.

In addition, as part of the financial strategy it has been developing within the National REDD+ strategy, in November 2020, the Green Climate Fund approved a \$54.1 million payment-for-results project for Costa Rica for emission reductions for 2014-2015<sup>17</sup>. In December 2021, the first disbursement of the results-based payment project was received for \$23,933,019.97. Likewise, in 2021, the first disbursement of the ERPA with the Carbon Fund was received for \$16,415,000.

## 1.2 Update on major drivers and lessons learned

**Costa Rica decoupled agricultural production from deforestation** by implementing solid legal frameworks, innovative agricultural and environmental policies, and Payment for Environmental Services schemes (REDD+ financial mechanisms), which together generated agricultural and livestock intensification, plus the growing development of Ecotourism. AFOLU emissions have decreased from 11.4 to 0.7 million tCO<sub>2</sub>-e yr<sup>-1</sup> (see Figure 1).

- **The Investment in REDD financial mechanisms promoted forest use over marginal agriculture.** By addressing drivers of forest loss, Costa Rica has demonstrated that emissions can be reduced effectively, as planned in the ER Program. During 2012-2021, the government of Costa Rica signed 448,407 ha<sup>18</sup> of PES contracts with private forest owners under the activities of Protection, Reforestation, Regeneration, and Forest Management. Deforestation in Costa Rica has historically been driven by **the lack of ecosystem service value** that incentivizes converting 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<sup>19</sup>. There have not been any new deforestation drivers identified and those listed in ER-PD. Deforestation drivers are also being addressed through the recently released (2020) Benefit Sharing Plan in the National REDD+ Strategy<sup>20</sup>. 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. Like 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 implementing of a comprehensive government plan on socioeconomic and environmental safeguards<sup>21</sup>, and the benefit-sharing mechanisms<sup>22</sup>.
- **The Intensification of agriculture and livestock** helped to produce a positive balance of mature forests loss and forest regeneration, improving the agriculture sector's added value and exports (see Figure 1). Between

<sup>16</sup> The projects in Mixed Systems are aimed at small producers who carry out forest/tree cover protection activities of 0.5 ha to 5 ha, non-tree covered areas, or in the process of regeneration of 0.5 ha to 5 ha and up to 1,600 trees in agroforestry systems. <https://www.fonafifo.go.cr/es/servicios/actividades-y-sub-actividades/>

<sup>17</sup> FP144 Costa Rica REDD-plus Results-Based Payments for 2014 and 2015 <https://www.greenclimate.fund/project/fp144>

<sup>18</sup> Contratos de PSA por tamaño de proyectos <https://www.fonafifo.go.cr/es/servicios/estadisticas-de-psa/>

<sup>19</sup> Plan de Implementación de la Estrategia Nacional REDD+ Costa Rica. Secretaría Ejecutiva REDD+ Costa Rica. 2017. Available at [https://ceniga.go.cr/wp-content/uploads/2020/02/plan\\_de\\_implementacion\\_enreddcr.pdf](https://ceniga.go.cr/wp-content/uploads/2020/02/plan_de_implementacion_enreddcr.pdf)

<sup>20</sup> 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>

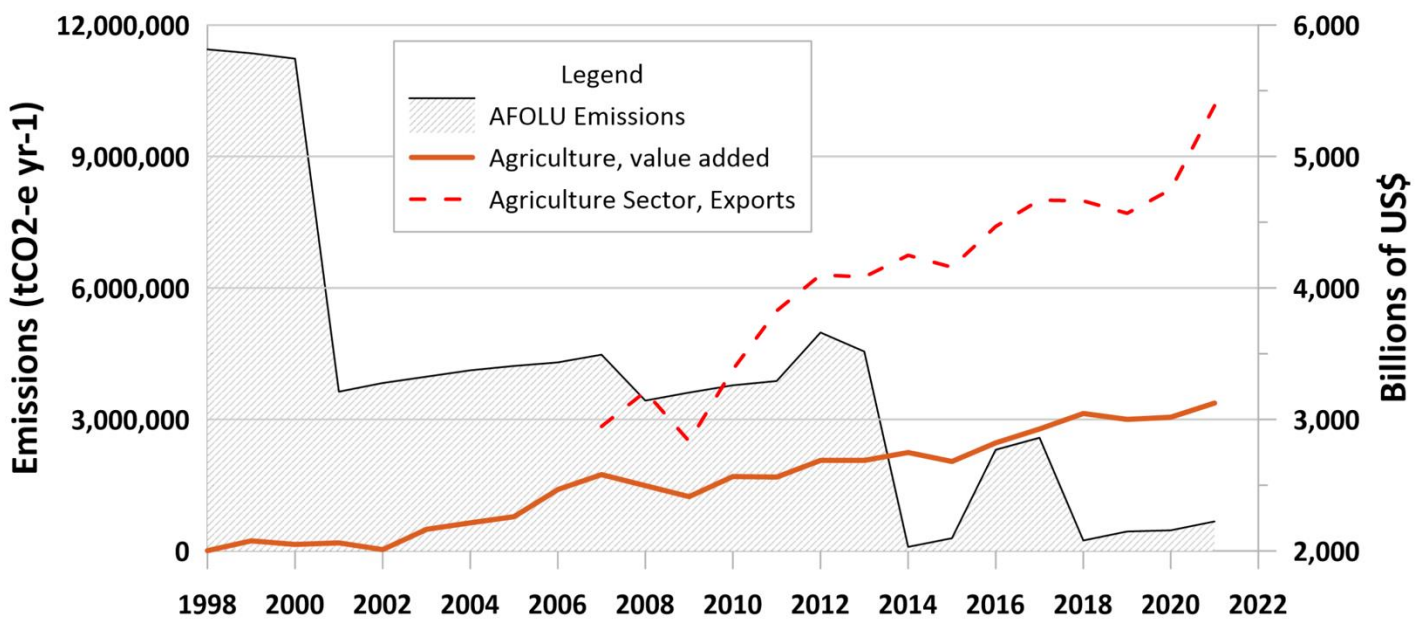
<sup>21</sup> Resumen del Diseño del Sistema de Información sobre Salvaguardas REDD+ en Costa Rica. 2017. FONAFIFO. 80 pp. [http://reddcr.go.cr/sites/default/files/centro-de-documentacion/propuesta\\_sis-redd\\_informe\\_final\\_-\\_fonafifo.pdf](http://reddcr.go.cr/sites/default/files/centro-de-documentacion/propuesta_sis-redd_informe_final_-_fonafifo.pdf)

<sup>22</sup> *ibid* 5.

2012 and 2021, the loss of mature forest was 37,285 hectares (61% for grasslands), while 194,914 hectares of forest were regenerated mainly from pasture lands (51%).

- **Ecotourism facilitated the Internalization of the benefits of biodiversity conservation.** Ecotourism in Costa Rica has become an effective forest conservation strategy. An explicit conservation mechanism, a local economic benefit, and strict monitoring and application of environmental regulations have accompanied ecotourism<sup>23</sup>.

**Regarding degradation, it is necessary to implement adjustments to reduce its emissions.** The emissions due to forest degradation have increased during the first and second monitoring periods (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. It is estimated that 49% of wood products come from forest plantations, 34% are imported, 12% are from agricultural lands, and 5% are from natural forests<sup>24</sup>. Costa Rica is addressing degradation through the financing mechanisms of PES and sustainable timber production initiatives. No other degradation drivers have been identified.



**Figure 1:** AFOLU emissions are decreasing while the agricultural sector's value-added and exports during 2012-2021 increased, showing that Costa Rica decouples deforestation from commodities production. Sources: World Bank (<https://datos.bancomundial.org/indicador/NV.AGR.TOTL.KD>), COMEX (<https://www.comex.go.cr/estadísticas-y-estudios/comercio-bienes/exportaciones/>), SINAMEC (<http://sinamecc.opendata.iunar.com/dashboards/21151/inventario-nacional-de-gases-de-efecto-invernadero-ingei/>) and National Forest Monitoring System.

<sup>23</sup> Brandt, J. S., & Buckley, R. C. (2018). A global systematic review of empirical evidence of ecotourism impacts on forests in biodiversity hotspots. *Current Opinion in Environmental Sustainability*, 32, 112–118. <https://doi.org/10.1016/j.cosust.2018.04.004>

<sup>24</sup> 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>

Table 1. Comparison of the emissions and sinks in the reference period (1998-2011) and the-ERPA monitoring periods (2018-2019 and 2020-2021).

Period	Average emissions from deforestation, t CO <sub>2</sub> e/y	Average removals from reforestation (Secondary forests), t CO <sub>2</sub> e/y	Average emissions from degradation, t CO <sub>2</sub> e/y	Average emissions from enhancements (forest remaining forests), t CO <sub>2</sub> e/y	Net forest cover emissions, t CO <sub>2</sub> e/y	Net forest land change remaining forests emissions, t CO <sub>2</sub> e/y	Total net emissions, t CO <sub>2</sub> e/y
<b>Reference period (1998-2011)</b>	5,985,795	-4,372,155	1,383,974	-411,896	1,613,640	972,078	2,585,717
<b>Monitoring period, pre-ERPA (2018-2019) <sup>[1]</sup></b>	840,167	-5,607,368	2,563,242	-406,144	-4,767,201	2,157,098	-2,610,103
<b>Monitoring period, pre-ERPA (2020-2021)</b>	558,827	-5,199,765	2,764,822	-509,222	-4,640,938	2,255,600	-2,385,338

<sup>[1]</sup> Average emissions from degradation have been updated after fixing an error in the canopy cover reference dataset produced during the importing process between the Collect Earth Desktop app and the Excel degradation tool.

## 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 UNFCCC in November 2019<sup>25</sup>. 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<sup>26</sup>.

The NFMS is part of the SIMOCUTE platform (National Monitoring System for Land Use, Land Use Cover, and Ecosystems, see Figure 2). 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 3). 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<sup>11</sup> 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<sup>27</sup>.

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 Meteorológico 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 Energía (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 Indígena (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+.

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<sup>25</sup> [https://redd.unfccc.int/files/4863\\_2\\_sistema\\_nacional\\_monitoreo\\_forestal\\_costa\\_rica.pdf](https://redd.unfccc.int/files/4863_2_sistema_nacional_monitoreo_forestal_costa_rica.pdf)

<sup>26</sup> Available at: <https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html> <sup>11</sup>

Accessible at <https://simocute.go.cr/>

<sup>27</sup> <https://simocute.go.cr/acerca/>

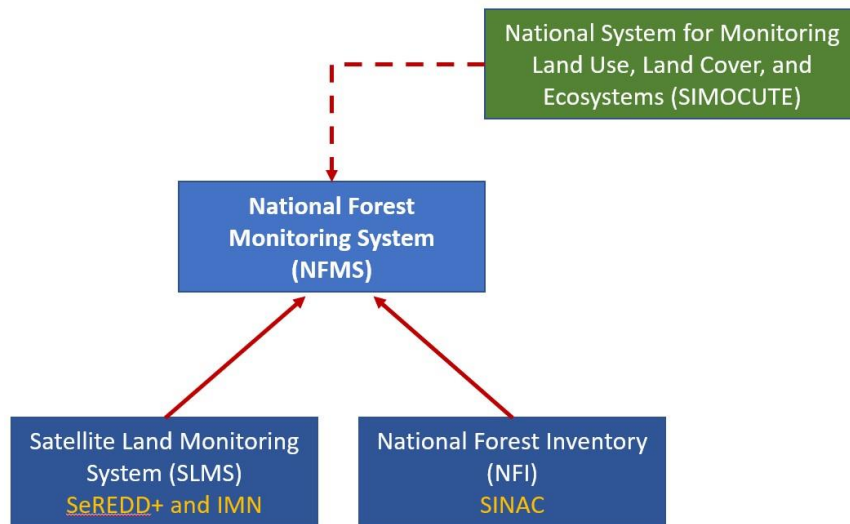


Figure 2: Organizational structure of the National Forest Monitoring System in Costa Rica.



Figure 3: 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 [Costa Rica REDD-plus Result-Based Payments Project](#) (RPB Project) support. This project will provide additional human resources and material inputs such as satellite imagery, hardware, software, and field monitoring equipment necessary for the REDD+ MRV implementation. This activity will strengthen national REDD+ monitoring, reporting, and verification capacities. 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 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 regularly determines 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<sup>28</sup>.
- **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.

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<sup>28</sup> 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](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 remains 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.

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

The key elements of the SLMS and the NFI, including methods, protocols, source of data, and the frequency of monitoring can be found in the section 3 of this report, the Annex 4 of the first Emission Reduction Monitoring Report<sup>29</sup> and Technical Annex Document<sup>30</sup>. 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)<sup>31</sup>, Ortiz-Malavassi (2017)<sup>32</sup>, and Aguilar (2020)<sup>33</sup>.

<sup>29</sup> The FCPF's first ER Monitoring Report of Costa Rica ER program can be accessed at the following link:

[https://www.forestcarbonpartnership.org/system/files/documents/costa\\_rica\\_fcpf\\_er\\_monitoring\\_report\\_1st\\_rp\\_final\\_0.pdf](https://www.forestcarbonpartnership.org/system/files/documents/costa_rica_fcpf_er_monitoring_report_1st_rp_final_0.pdf)

<sup>30</sup> 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](https://unfccc.int/sites/default/files/resource/4863_3_iba-2019-anexotecnico_Edited.pdf)

<sup>31</sup> 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/ygijw6zq00a1qtbm/Informe\\_tecnico\\_feb\\_2015.pdf?dl=0](https://www.dropbox.com/s/ygijw6zq00a1qtbm/Informe_tecnico_feb_2015.pdf?dl=0)

<sup>32</sup> 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-DNkelM8y7gBLrKou-f7LI-G/view?usp=sharing>

<sup>33</sup> 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/1ERutZo6vNI6MXUCmlrky7wiaeOqQLMqh/view?usp=sharing>

- **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)<sup>34</sup>, Rodríguez (2018)<sup>35</sup>, Coto (2018)<sup>36</sup>, and Obando (2019)<sup>37</sup>.

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 plot distribution among forest strata<sup>38</sup> 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), nongovernment 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 using 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 concerning conservation, restoration, reforestation, or management. In that same sense, many local and regional forestry producer organizations provide regency services to interested parties and have their capacities strengthened through PES. It is envisioned to strengthen these capacities through different lines of work incorporated into policies, actions, and tasks of the PRE.

<sup>34</sup> 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>

<sup>35</sup> 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>

<sup>36</sup> 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/1svYPJGEoBHpln72sg4eipf6uZkp6lllM/view?usp=sharing>

<sup>37</sup> 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>

<sup>38</sup> Recomendaciones para la Medición, Reporte, y Verificación (MRV) de REDD+. 2016. Report from the CDI, US Forest Service, and FAO UNREDD. 33 pp.

## 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 the 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 4).

Costa Rica has developed a tool to estimate emissions and removals from deforestation and reforestation - FREL & MRV TOOL CR.xlsx<sup>39</sup>, and another for the estimate of emission and removals from degradation in permanent forest lands – Herramienta-degradacion.xlsx<sup>40</sup>.

**FREL tool:** Details of the FREL tool can be found in the START spreadsheet and its manual (Manual de la Herramienta FREL & MRV Tool – UNFCCC.pdf in Spanish<sup>41</sup>). The tool is organized in the following sections:

#### Setting sections that users must not modify:

- 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: This spreadsheet aims to calculate the carbon stocks (in tCO<sub>2</sub>-e ha<sup>-1</sup>) 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 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”<sup>42</sup>) 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 calculating 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 ensure, 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 matrix structure 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

<sup>39</sup> The FREL Tool can be accessed in the following link: [https://docs.google.com/spreadsheets/d/103jZDLVaK3bKC-QQwBV4CmSYj\\_sSZ5nh?rtmpof=true&authuser=mrvreddcr%40gmail.com&usp=drive\\_fs](https://docs.google.com/spreadsheets/d/103jZDLVaK3bKC-QQwBV4CmSYj_sSZ5nh?rtmpof=true&authuser=mrvreddcr%40gmail.com&usp=drive_fs)

<sup>40</sup> Degradation tool can be accessed in the following link:

[https://docs.google.com/spreadsheets/d/11r7J0a6BHZx5aWyzC45UatWy3XAlnf0?rtmpof=true&authuser=mrvreddcr%40gmail.com&usp=drive\\_fs](https://docs.google.com/spreadsheets/d/11r7J0a6BHZx5aWyzC45UatWy3XAlnf0?rtmpof=true&authuser=mrvreddcr%40gmail.com&usp=drive_fs)

<sup>41</sup> 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](https://drive.google.com/file/d/14CsE_rpBBrEJgyUTplziKksGGVm_YtL_/view?usp=sharing)

<sup>42</sup> A copy of Carbon Densities database can be download at the following link:

[https://drive.google.com/file/d/1Lj8pbd0EuiVoS7JuMc8ps\\_OwD12MUuH/view?usp=sharing](https://drive.google.com/file/d/1Lj8pbd0EuiVoS7JuMc8ps_OwD12MUuH/view?usp=sharing)

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 AAAAAA” sheets. The calculation is made in matrices of land use changes and assumes that in the “AAAA-AA” period, the areas converted annually are equal.
- viii. ER AAAA: These spreadsheets calculate GHG emissions and removals related to the land use change summarized by forest type 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 analyses are performed in a separate 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)<sup>43</sup>. The tool facilitates the following calculations:

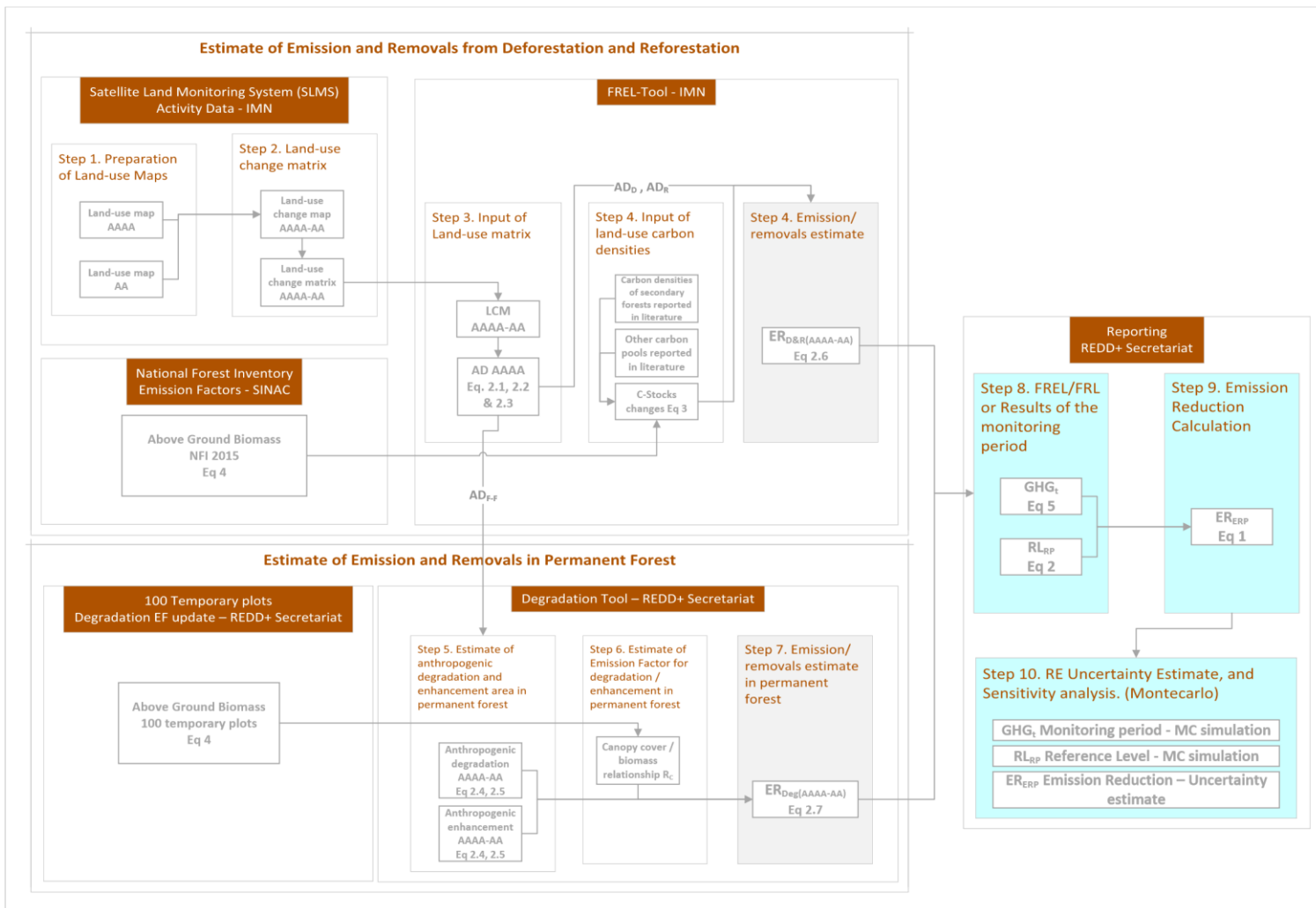
- Segregation of interpretation points between anthropic and natural carbon flux areas to eliminate natural changes from emissions accounting since the ER program cannot control them.
- Calculation of the number of points in each forest state transition. In this step, the canopy interpretation assessment 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:

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<sup>43</sup> Winrock International. (2018). Ejercicio : estimación de emisiones por actividades en bosques que permanecen como tales. Retrieved from <https://drive.google.com/file/d/1Mk8MACXEKDR0XQg2UP7t4FDqQmc8Q5S9/view?usp=sharing>

- 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.
- 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 4:** 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

$$ER_{ERP,t} = RL_{RP} - GHG_t \quad \text{Equation 1}$$

Where:

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

#### 2.2.2.1.1 Reference Level ( $RL_t$ )

The RL estimation may be found in Annex 4 of the first ER-MR, 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:

$$RL_{RP} = \frac{\sum_{t=1}^{RP} ER_{RA,t}}{RP} = \frac{\sum_{t=1}^{RP} \sum_{i=1}^l (AD_{RAi,t} * EF_{RAi,t})}{RP} \quad \text{Equation 2}$$

Where:

$ER_{RA,t}$	=	Emissions or removals associated to REDD+ activity $RA$ in year $t$ ; $tCO_2-e \text{ yr}^{-1}$
$AD_{RAi,t}$	=	AD associated to REDD+ activity $RA$ for the land use transition $i$ in year $t$ ; $ha \text{ yr}^{-1}$
$EF_{RAi,t}$	=	EF associated to REDD+ activity $RA$ applicable to the land use transition $i$ in year $t$ ; $tCO_2-e \text{ ha}^{-1}$
RP	=	Reference Period in years
$i$	=	A land use transition represented in a cell of the land use change matrix; dimensionless
$l$	=	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 ( $AD_D$ )

$$AD_{D_{i,t}} = |D_{i,t}| * 0.81, \text{ Equation 2.1}$$

Where  $|D_{i,t}|$  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 ( $AD_R$ )

$$AD_{R_{i,t}} = |R_{i,t}| * 0.81, \text{ Equation 2.2}$$

Where  $|R_{i,t}|$  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 ( $AD_{F-F}$ )

$$AD_{F-F_{i,t}} = |F - F_{i,t}| * 0.81, \text{ Equation 2.3}$$

Where  $|F - F_{i,t}|$  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<sub>Deg</sub>)**

$$AD_{Deg_k} = \frac{|Deg_k|}{N} * AD_{F-F_t} \quad \text{Equation 2.4}$$

**Activity Data of Permanent Forest Regeneration (AD<sub>E</sub>)**

$$AD_{E_k} = \frac{|E_k|}{N} * \sum_{i=1}^I AD_{F-F_{i,t}} \quad \text{Equation 2.5}$$

**Emissions from Deforestation & Removals (E<sub>D&R(AAAA-AA)</sub>)**

$$E_{D\&R(AAAA-AA)} = \sum_{k=1}^I AD_{D_{i,t}} * EF_{D_i} + \sum_{k=1}^I AD_{R_{i,t}} * EF_{R_i} \quad \text{Equation 2.6}$$

**Emission & Removals from Degradation (E<sub>Deg(AAAA-AA)</sub>)**

$$E_{Deg(AAAA-AA)} = \sum_{k=1}^I AD_{Deg_k} * EF_{Deg_k} + \sum_{k=1}^I AD_{E_k} * EF_{E_k} \quad \text{Equation 2.7}$$

Where  $|Deg_{i,t}|$  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. Where  $|E_k|$  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. 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 zero and vice versa). 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 ( $\Delta C$ ) 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:

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

Where:

- $\Delta C$  = C stock changes associated to the land use transition  $i$  in year  $t$ ; tCO<sub>2</sub>-e ha<sup>-1</sup>
- $C_{t1}$  = C stock at time  $t1$ , t CO<sub>2</sub> ha<sup>-1</sup>  $t1$  in all cases was the 1<sup>st</sup> 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<sub>2</sub> ha<sup>-1</sup>  $t2$  in all cases was the 31<sup>st</sup> 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<sup>44</sup> and 20<sup>45</sup> 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<sub>2</sub>

<sup>44</sup> 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  $\Delta C$  in conversions of non-Forest land use categories to Forest land and conversions of other land use categories to permanent crops.

<sup>45</sup> 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  $\Delta C$  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.

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

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

Where:

- $B_{tot}$  = Total biomass stock for the land use category  $LU$ ;  $tCO_2\text{-e ha}^{-1}$ .  
 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  $LU$ ;  $tCO_2\text{-e ha}^{-1}$   
 BGB is below-ground biomass for land use category  $LU$ ;  $tCO_2\text{-e ha}^{-1}$   
 DW is dead wood biomass for land use category  $LU$ ;  $tCO_2\text{-e ha}^{-1}$   
 L is litter biomass for land use category  $LU$ ;  $tCO_2\text{-e ha}^{-1}$
- 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

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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 ( $GHG_t$ )

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

$$GHG_t = \frac{\sum_t^{MP} ER_{RA,t}}{MP} = \frac{\sum_{t=1}^{MP} \sum_{i=1}^I (AD_{RAi,t} * EF_{RAi,t})}{MP} \quad \text{Equation 5}$$

Where:

- $ER_{RA,t}$  = Emissions or removals associated to REDD+ activity RA in year t;  $tCO_2\text{-e yr-1}$   
 $AD_{RAi,t}$  = AD associated to REDD+ activity RA for the land use transition i in year t;  $ha\ yr\text{-1}$   
 $EF_{RAi,t}$  = EF associated to REDD+ activity RA applicable to the land use transition i in year t;  $tCO_2\text{-e ha-1}$   
 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<sub>D</sub>** and **AD<sub>R</sub>**) are calculated differently from Degradation and Enhancement Activity Data (**AD<sub>Deg</sub>** and **AD<sub>E</sub>**). 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<sub>D</sub>)**

$$AD_{D_{i,t}} = |D_{i,t}| * 0.81, \text{ Equation 5.1}$$

Where  $|D_{i,t}|$  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<sub>R</sub>)**

$$AD_{R_{i,t}} = |R_{i,t}| * 0.81, \text{ Equation 5.2}$$

Where  $|R_{i,t}|$  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<sub>F-F</sub>)**

$$AD_{F-F_{i,t}} = |F - F_{i,t}| * 0.81, \text{ Equation 5.3}$$

Where  $|F - F_{i,t}|$  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<sub>Deg</sub>)**

$$AD_{Deg_k} = \frac{|Deg_k|}{N} * AD_{F-F_t} \text{ Equation 5.4}$$

Where  $|Deg_{i,t}|$  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<sub>E</sub>)**

$$AD_{E_k} = \frac{|E_k|}{N} * \sum_{i=1}^I AD_{F-F_{i,t}} \text{ Equation 5.5}$$

Where  $|E_{i,t}|$  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<sub>D&R(AAAA-AA)</sub>**

$$E_{D\&R(AAAA-AA)} = \sum_{k=1}^I AD_{D_{i,t}} * EF_{D_i} + \sum_{k=1}^I AD_{R_{i,t}} * EF_{R_i} \text{ Equation 5.6}$$

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 zero and vice versa).

**Emission & Removals from Degradation E<sub>Deg(AAAA-AA)</sub>**

$$E_{Deg(AAAA-AA)} = \sum_{k=1}^I AD_{Deg_k} * EF_{Deg_k} + \sum_{k=1}^I AD_{E_k} * EF_{E_k} \text{ Equation 5.7}$$

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<sup>46</sup>.

<b>Parameters:</b>	<b>Activity Data of Deforestation (AD<sub>D</sub>) Eq. 2.1</b> <b>Activity Data of Reforestation (AD<sub>R</sub>) Eq. 2.2</b> <b>Forest remaining forests (AD<sub>F-F</sub>) Eq. 2.3</b>
<b>Description:</b>	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
<b>Data unit:</b>	Hectares
<b>Source of data</b>	
<b>Introduction</b>	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) <sup>47</sup> 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 <sup>48, 49, 50</sup> :
<b>Data sources for estimating activity data:</b>	The construction of the AD time series required the following sources of data: <ul style="list-style-type: none"> <li>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).</li> <li>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".</li> <li>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".</li> <li>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.</li> </ul>

<sup>46</sup> All AD parameters listed in table 2 sourced from the same survey.

<sup>47</sup> 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/1XulVBwfZNam6aclksq-ZMQoK\\_ISqy0V2?usp=sharing](https://drive.google.com/drive/folders/1XulVBwfZNam6aclksq-ZMQoK_ISqy0V2?usp=sharing)

<sup>48</sup> 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.

<sup>49</sup> 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](https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf)

<sup>50</sup> 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](https://www.forestcarbonpartnership.org/system/files/documents/Costa_Rica_ERPD_EN_Oct24-2018_clean.pdf)

<b>Methods for mapping land-use and land-use change</b>	
<b>Selection of images</b>	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.
<b>Pre-processing and Geometric validation</b>	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.
<b>Radiometric normalization</b>	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) <sup>51</sup> . The normalization of the time series used as a reference the zenith angle 36.90° corresponding to February 17, 2013.
<b>Random Forest classification</b>	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.

<sup>51</sup> 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.

## 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 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<sup>52</sup>):
  - 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 (ICAFFE), 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, ICAFFE, 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".

<sup>52</sup> 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](https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf)

<b>Activity Data calculation</b>	AD for land use change activities such as <i>deforestation</i> and <i>reforestation</i> 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 <sup>53</sup> ".
<b>Value applied in reference period:</b>	
	<b>1998-2011:</b> <ul style="list-style-type: none"> <li>• Total anthropogenic deforestation: 30,439 ha yr<sup>-1</sup></li> <li>• Primary forest anthropogenic deforestation: 13,147 ha yr<sup>-1</sup></li> <li>• Secondary forest and tree plantation anthropogenic deforestation: 17,292 ha yr<sup>-1</sup></li> </ul>
<b>QA/QC procedures applied</b>	
<b>Introduction</b>	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:
<b>Download and satellite image preparation</b>	<ol style="list-style-type: none"> <li>1. Verification of file storage errors in digital media that could affect reading the data by the analyst responsible for download support images.</li> <li>2. Previewing and verification of the satellite image quality and metadata by the analyst responsible for downloading support images.</li> <li>3. Previewing and verification of the satellite image quality and metadata by the supervisor.</li> </ol>
<b>Image orthorectification</b>	<ol style="list-style-type: none"> <li>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).</li> <li>2. Geometric control of orthorectified images by taking checkpoints in each scene in a regularly distributed grid.</li> <li>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).</li> <li>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.</li> </ol>
<b>Radiometric normalization:</b>	<ol style="list-style-type: none"> <li>5. Radiometric normalization to reduce the differences between the time-series images.</li> </ol>
<b>Generation of cloud and shadow masks</b>	<ol style="list-style-type: none"> <li>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.</li> <li>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.</li> </ol>
<b>Land use classification:</b>	<ol style="list-style-type: none"> <li>8. Analysts perform an iterative process of classification, verification of results, error detection, and review of areas and training points.</li> </ol>

<sup>53</sup> The FREL Tool can be accessed in the following link:

[https://drive.google.com/file/d/1wiVsHpP\\_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing](https://drive.google.com/file/d/1wiVsHpP_b5kEVkbb4GdQqWaQDDzwyZnw/view?usp=sharing)

	<p>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.</p> <p>10. Visual verification and validation of classified images by comparing them with the available high-resolution image.</p>
<b>Preparation of land-use maps:</b>	<p>11. Visual check of mosaics and identify information gaps and sensor failures on each time series' images.</p> <p>12. Visual verification of the maps generated after filling the gaps with global data.</p> <p>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.</p> <p>14. Manual edition of the time-series classification to improve land use mapping, largely aimed at decreasing high classification errors.</p>
<b>Visual verification and validation of land-use change map:</b>	<p>15. Visual verification of the country's main deforestation and reforestation areas between consecutive years of the series to detect classification errors.</p> <p>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.</p>
<b>Uncertainty associated with this parameter:</b>	
<b>Uncertainty associated with this parameter:</b>	<p>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)<sup>54</sup> 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 (nonforest 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)<sup>55</sup>. 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)<sup>56</sup>. The accuracy assessment analysis is presented in the Excel file "CDI_CostaRicaREL_AnalisisExactitud_MCS2000-2001 vs MCS2010-2011"<sup>57</sup>. 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):</p> <p>Uncertainty of hectares of deforestation from 1998-2011: 26%</p> <p>Uncertainty of hectares of non-forest that changed to forest land: 51%</p> <p>Uncertainty of hectares of forests remaining forests in 1998-2011: 7%</p>

<sup>54</sup> Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148, 42-57.

<sup>55</sup> 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](https://www.forestcarbonpartnership.org/system/files/documents/Costa_Rica_ERPD_EN_Oct24)[https://www.forestcarbonpartnership.org/system/files/documents/Costa\\_Rica\\_ERPD\\_EN\\_Oct24-2018\\_clean.pdf](https://www.forestcarbonpartnership.org/system/files/documents/Costa_Rica_ERPD_EN_Oct24-2018_clean.pdf)

<sup>56</sup> 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-lfdZ-BzFxfqrGO1pwbp537HL1?usp=sharing>

<sup>57</sup> 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](https://drive.google.com/file/d/1wUfwkW4E74Y-AZHcesr4coNis0e_SabC/view?usp=sharing)

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

<b>Parameters:</b>	<b>Activity Data of Degradation (<math>AD_{Deg}</math>) Eq. 2.4</b> <b>Activity Data of Permanent Forest Regeneration (<math>AD_E</math>) Eq. 2.5</b>
<b>Description:</b>	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
<b>Data unit:</b>	Hectares
<b>Source of data</b>	
<b>Introduction</b>	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) <sup>58</sup> .
<b>Type of sampling</b>	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.
<b>Sampling Unit</b>	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.
<b>Number of Sampling Units</b>	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.
<b>Classification scheme</b>	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: <ul style="list-style-type: none"> <li>a. Intact to Degraded forest.</li> <li>b. Intact to Very degraded forest.</li> <li>c. Degraded to Very degraded forest.</li> </ul> Forest enhancement: <ul style="list-style-type: none"> <li>d. Very degraded to intact forest.</li> <li>e. Very degraded to degraded forest.</li> <li>f. Degraded to Intact forest.</li> </ul> No Condition changes: <ul style="list-style-type: none"> <li>g. Stable intact forest</li> <li>h. Stable degraded forest</li> <li>i. Stable very degraded forest</li> </ul>

<sup>58</sup> 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-DNkelM8y7gBLrKou-f7LI-G/view?usp=sharing>

<b>Imagery Sources</b>	<p>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:</p> <table border="1" data-bbox="578 527 1317 848"> <thead> <tr> <th data-bbox="578 527 716 596">Monitoring Year</th> <th data-bbox="716 527 899 596">Imagery date range</th> <th data-bbox="899 527 1317 596">Data sources</th> </tr> </thead> <tbody> <tr> <td data-bbox="578 596 716 697">1998</td> <td data-bbox="716 596 899 697">January 1997 – December 2005</td> <td data-bbox="899 596 1317 697"> <ul style="list-style-type: none"> <li>• Orthophotos TERRA 1997.</li> <li>• Google Earth imagery repository</li> <li>• Mission CARTA 2005</li> </ul> </td> </tr> <tr> <td data-bbox="578 697 716 772">2011</td> <td data-bbox="716 697 899 772">July 2011 – June 2012</td> <td data-bbox="899 697 1317 772"> <ul style="list-style-type: none"> <li>• Google Earth imagery repository</li> </ul> </td> </tr> <tr> <td data-bbox="578 772 716 848">2016</td> <td data-bbox="716 772 899 848">July 2015 – June 2016</td> <td data-bbox="899 772 1317 848"> <ul style="list-style-type: none"> <li>• Google Earth imagery repository</li> </ul> </td> </tr> </tbody> </table>	Monitoring Year	Imagery date range	Data sources	1998	January 1997 – December 2005	<ul style="list-style-type: none"> <li>• Orthophotos TERRA 1997.</li> <li>• Google Earth imagery repository</li> <li>• Mission CARTA 2005</li> </ul>	2011	July 2011 – June 2012	<ul style="list-style-type: none"> <li>• Google Earth imagery repository</li> </ul>	2016	July 2015 – June 2016	<ul style="list-style-type: none"> <li>• Google Earth imagery repository</li> </ul>												
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<b>Interpretation Key</b>	<p>The land cover class keys used to determine canopy cover for the years 1998, 2011, and 2016 are the following:</p> <table data-bbox="773 982 1136 1350"> <thead> <tr> <th data-bbox="773 982 922 1010">Code</th> <th data-bbox="922 982 1136 1010">Land cover class</th> </tr> </thead> <tbody> <tr><td data-bbox="773 1010 922 1037">1100</td><td data-bbox="922 1010 1136 1037">Trees</td></tr> <tr><td data-bbox="773 1037 922 1064">1200</td><td data-bbox="922 1037 1136 1064">Shrubs</td></tr> <tr><td data-bbox="773 1064 922 1092">1300</td><td data-bbox="922 1064 1136 1092">Herbaceous</td></tr> <tr><td data-bbox="773 1092 922 1119">1400</td><td data-bbox="922 1092 1136 1119">Palm</td></tr> <tr><td data-bbox="773 1119 922 1146">1500</td><td data-bbox="922 1119 1136 1146">Bromeliads</td></tr> <tr><td data-bbox="773 1146 922 1173">1600</td><td data-bbox="922 1146 1136 1173">Greenhouse</td></tr> <tr><td data-bbox="773 1173 922 1201">1700</td><td data-bbox="922 1173 1136 1201">Other vegetation</td></tr> <tr><td data-bbox="773 1201 922 1228">2000</td><td data-bbox="922 1201 1136 1228">No vegetation</td></tr> <tr><td data-bbox="773 1228 922 1255">3000</td><td data-bbox="922 1228 1136 1255">Water</td></tr> <tr><td data-bbox="773 1255 922 1283">4000</td><td data-bbox="922 1255 1136 1283">Clouds and shadows</td></tr> <tr><td data-bbox="773 1283 922 1310">5000</td><td data-bbox="922 1283 1136 1310">Not classifiable</td></tr> </tbody> </table>	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
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<b>Data analysis</b>	<p>The country developed a tool for calculating emissions and removals on permanent forest lands ("Herramienta_degradación.xlsx"<sup>59</sup>). 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<sup>60</sup> 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.</p>
<b>Value applied in reference period:</b>	
	<ul style="list-style-type: none"> <li>• <b>2,233,119</b> hectares of forests remaining forests in the reference period (1998-2011)</li> <li>• <b>145,556</b> hectares of anthropogenic degradation (1998-2011)</li> <li>• <b>157,739</b> hectares of anthropogenic forest enhancement (1998-2011)</li> </ul>
<b>QA/QC procedures applied</b>	
	<p>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:</p> <p><b>Data registry forms:</b> The canopy cover change information was recorded in standard Collect Earth Desktop forms.</p> <p><b>Variability between interpreters:</b> 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.</p> <p><b>Validation of the coverage classification:</b> The supervisor validated land cover classification with National Forest Inventory land cover data. This information was available only for the supervisors.</p> <p><b>Imagery co-registration:</b> Google Earth images can show displacements, which became evident when the interpreter compares the same area for different years. Potere (2008)<sup>61</sup> 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.</p> <p><b>Data consistency:</b> The supervisor reviewed the existence of discrepancies between cover class and land use.</p>
<b>Uncertainty associated with this parameter:</b>	

<sup>59</sup> Degradation tool can be accessed in the following link:

[https://drive.google.com/file/d/1GG3Z\\_QMWBKGNRdXnF\\_TdWP1ipH9dX5iH/view?usp=sharing](https://drive.google.com/file/d/1GG3Z_QMWBKGNRdXnF_TdWP1ipH9dX5iH/view?usp=sharing)

<sup>60</sup> 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\\_metadatos?k=Y2FwYW1ldGFkYXRvczo6Y2FwYT06SUdOXzU6OnZpYXNfNTAwMA](http://www.snitcr.go.cr/Metadatos/full_metadatos?k=Y2FwYW1ldGFkYXRvczo6Y2FwYT06SUdOXzU6OnZpYXNfNTAwMA)

<sup>61</sup> 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>

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

<b>Parameters:</b>	<b>Carbon density of aboveground tree or woody biomass (<math>C_{AGB}</math>) Eq. 4</b> <b>Carbon density of belowground biomass (<math>C_{BGB}</math>). Eq. 4.</b> <b>Carbon density of dead wood biomass (<math>C_{DWB}</math>). Eq. 4</b> <b>Carbon density of litter (<math>C_L</math>). Eq. 4</b>
<b>Description:</b>	<ul style="list-style-type: none"> <li>• <math>C_{AGB}</math>: Amount of carbon (C) contained in aboveground biomass per forest hectare, converted to CO<sub>2</sub>e multiplying by a factor of 44/12 (i.e., the molecular weight of a CO<sub>2</sub> molecule over the molecular weight of a C molecule).</li> <li>• <math>C_{BGB}</math>: Amount of C contained in belowground forest biomass per forest hectare, converted to CO<sub>2</sub>e multiplying by a factor of 3.67 (i.e., the molecular weight of a CO<sub>2</sub> molecule over the molecular weight of a C molecule).</li> <li>• <math>C_{DWB}</math>: Amount of C contained in dead wood forest biomass (standing and lying) per forest hectare, converted to CO<sub>2</sub>e multiplying by a factor of 3.67 (i.e., the molecular weight of a CO<sub>2</sub> molecule over the molecular weight of a C molecule).</li> <li>• <math>C_L</math>: Amount of CO<sub>2</sub>e contained in litter forest biomass per forest hectare.</li> </ul>
<b>Data unit:</b>	Tonnes of CO <sub>2</sub> e per hectare
<b>Source of Data</b>	
<b>Introduction</b>	<p>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.</p> <ul style="list-style-type: none"> <li>• <b>Carbon pool of aboveground tree or woody biomass (<math>C_{AGB}</math>):</b> Carbon pool of aboveground tree or woody biomass for each Primary Forest type (<math>C_{AGB}</math>) is the area-weighted average of <math>C_{AGB}</math> stock value from 2015 field campaign performed for the National Forest Inventory.</li> <li>• <b>Carbon pool of belowground biomass (<math>C_{BGB}</math>):</b> Derived directly from <math>C_{AGB}</math> data following the Cairns et al., (1997) formula.</li> <li>• <b>Carbon pool of dead wood biomass (<math>C_{DWB}</math>):</b> Average values of direct measurements reported in literature. The value was used to develop a ratio of <math>C_{DWB}</math> over <math>C_{AGB}</math> used for <math>AD_D</math>, <math>AD_{F-F}</math>, and <math>AD_R</math>. 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.</li> <li>• <b>Carbon pool of litter (<math>C_L</math>):</b> Average values of direct measurements reported in literature. The value was used to develop a ratio of <math>C_L</math> over <math>C_{AGB}</math> used for <math>AD_D</math>, <math>AD_{F-F}</math>, and <math>AD_R</math>. 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.</li> </ul>
<b>Source of Data of Above Ground Biomass for Primary Forest</b>	<b>Type of sampling:</b> 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

	<p>imagery (REDD/CCAD-GIZ-SINAC, 2015)<sup>62</sup> and plots were equidistantly allocated within each stratum.</p> <p><b>Sampling Unit:</b> 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)<sup>63</sup>:</p> <ul style="list-style-type: none"> <li>• 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)</li> <li>• Secondary Sampling Unit (UMS for its acronym in Spanish) for measurement of saplings with 2cm ≤ DBH &lt; 10cm, and height &gt; 1.5m.</li> <li>• Third-order Sampling Unit (UMT for its acronym in Spanish) for measurement of live non-tree vegetation, including seedlings (DBH &lt; 2cm and height &lt; 1.5m), were taken (light grey circles)</li> <li>• Fourth-order Sampling Unit (UMC for its acronym in Spanish) to measure the abundance of species.</li> <li>• Fifth-order Sampling Unit (UMH) to measure litter.</li> <li>• Lying deadwood sampling (UMM) to measure the lying deadwood's diameter in the 20m transects.</li> </ul> <p>Soil sampling of the first 30cm with cylinder method.</p> <p><b>Number of Sampling Units:</b> 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.</p>
<p><b>Source of Data of Above Ground Biomass for Secondary Forest</b></p>	<p>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)<sup>64</sup> 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.</p> <p>Wet and Rain Forests (Cifuentes, 2008, Table 2.5, p. 42, equation for "Tropical Wet"):</p> $TAGB_t = B_{max} * [1 - e^{(-0.0186*t)}]_1$ <p>Moist Forests (Cifuentes, 2008,, Table 2.5, p. 42, equation for "Tropical Premontane Wet Transition to Basal-Atlantic"):</p> $TAGB_t = B_{max} * [1 - e^{(-0.0348*t)}]_1$ <p>Dry Forests (Cifuentes, 2008,, Table 2.5, p. 42, equation for "Tropical Dry"):</p> $TAGB_t = B_{max} * [1 - e^{(-0.113*t)}]_{5.1411}$ <p>Mangroves and Palm Forest the following linear equation was applied:</p> $TAGB_t = \frac{max}{100} * B$ $TAGB_t = B_{max} \quad , \text{ when } t > 100$

<sup>62</sup> 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-imprensa.pdf>

<sup>63</sup> 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-imprensa.pdf>

<sup>64</sup> 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/1FsiTVc78EHcU0gQ4JfFJFSIPqesm3JFW/view?usp=sharing>

	It was assumed that the maximum biomass in secondary forests ( $B_{max}$ ) equals the biomass estimated for primary forests.
<b>Source of data of Litter and Deadwood in primary and secondary forest</b>	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 <sup>-1</sup> ), using IPCC's default carbon fraction (0.47) when the values were reported in tons of dry matter (t d.m. ha <sup>-1</sup> ). 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 <sup>65</sup> and C-STOCKS sheet of FREL TOOL <sup>66</sup> . The literature review employed the following criteria for compiling the reported value: • The publication reported data from direct measurements carried out in Costa Rica <ul style="list-style-type: none"> <li>• Measurements were carried out after the year 2005</li> <li>• Data were sufficiently disaggregated by reporting values of carbon stocks per land use categories and per carbon pool sampled</li> <li>• The publications included information on uncertainties related to the carbon stock estimates</li> </ul>
<b>Source of data of carbon stocks of non-Forest land uses</b>	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. <ul style="list-style-type: none"> <li>• <b>Cropland:</b> 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.</li> <li>• <b>Grassland:</b> carbon stocks were estimated as the average values reported in different carbon pools in the selected studies.</li> <li>• <b>Settlements and (non-forested) Wetlands:</b> no studies could be found reporting biomass values for these categories. It was assumed that their carbon stock is zero.</li> <li>• <b>Other Land:</b> studies were found reporting carbon stocks for <i>Paramo</i>. In the case of <i>Bare Soil</i>, it was assumed carbon stocks are zero.</li> </ul>

<sup>65</sup> BaseDeDatos\_v5.xlsx can be accessed at the following link:

[https://drive.google.com/file/d/1d6QqYQci7\\_Qo7DJhS5eOKgCqLFDXhttps://drive.google.com/file/d/1d6QqYQci7\\_Qo7DJhS5eOKgCqLFDX-rFX/view?usp=sharingrFX/view?usp=sharing](https://drive.google.com/file/d/1d6QqYQci7_Qo7DJhS5eOKgCqLFDXhttps://drive.google.com/file/d/1d6QqYQci7_Qo7DJhS5eOKgCqLFDX-rFX/view?usp=sharingrFX/view?usp=sharing)

<sup>66</sup> The FREL Tool can be accessed in the following link:

[https://docs.google.com/spreadsheets/d/103iZDLVaK3bKC-OQwBV4CmSYj\\_sSZ5nh/edit?usp=sharing&oid=101528572552038951719&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/103iZDLVaK3bKC-OQwBV4CmSYj_sSZ5nh/edit?usp=sharing&oid=101528572552038951719&rtpof=true&sd=true)

## 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)<sup>67</sup> moist forests allometric equation as follows:

$$AGB = \exp(-2.977 + \ln(\rho * DBH^2 * HT)) \text{ Where:}$$

AGB: aboveground biomass (kg)  $\rho$ : wood specific gravity (g/cm<sup>3</sup>). 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 m<sup>2</sup>) that is occupied by the plot as follows:

$$\text{ScalingFactor} = \frac{10,000m^2}{1,000m^2} = 10$$

Where:

10,000m<sup>2</sup>: Area of one hectare (m<sup>2</sup>)

1,000m<sup>2</sup>: Area of INF-CR rectangular plot (20m x 50m)

- **Below ground biomass (BGB):** BGB is derived directly from Cairns et al., (1997).<sup>68</sup> equation, to estimate C<sub>BGB</sub> from C<sub>AGB</sub> data:

$$BGB = \exp(-1.085 + 0.9256 * \ln(AGB)) \text{ Where:}$$

BGB: belowground biomass (t d.m. ha<sup>-1</sup>)

AGB: aboveground biomass (t d.m. ha<sup>-1</sup>)

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 ( $\Delta C$ )** 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

Primary Forest type	Area-weighted average		
	t C <sub>AGB</sub> ha <sup>-1</sup>	t C <sub>DWB</sub> ha <sup>-1</sup>	t C <sub>L</sub> ha <sup>-1</sup>
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

<sup>67</sup> Chave J et al. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia* 145: pp. 87-99.

<sup>68</sup> 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.

<p><b>Carbon stocks in Secondary Forest</b></p>	<p>The table below shows the B<sub>max</sub> values used in the equations above to calculate <math>TAGB_t</math> from the secondary forest stand age.</p> <table border="1" data-bbox="743 296 1182 457"> <thead> <tr> <th>Secondary Forest Type</th> <th>B<sub>max</sub> (t dry mass ha<sup>-1</sup>)</th> </tr> </thead> <tbody> <tr> <td>Wet and Rain Forests</td> <td>445</td> </tr> <tr> <td>Moist Forests</td> <td>262</td> </tr> <tr> <td>Dry Forests</td> <td>155</td> </tr> </tbody> </table>	Secondary Forest Type	B <sub>max</sub> (t dry mass ha <sup>-1</sup> )	Wet and Rain Forests	445	Moist Forests	262	Dry Forests	155								
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<p><b>Carbon stocks of non-Forest land uses</b></p>	<table border="1" data-bbox="651 569 1276 890"> <thead> <tr> <th>Non-forest land uses</th> <th>Area-weighted average t C<sub>AGB</sub> ha<sup>-1</sup></th> </tr> </thead> <tbody> <tr> <td>Permanent crop, wooded, cropland</td> <td>16</td> </tr> <tr> <td>Annual crop, wooded, cropland</td> <td>0</td> </tr> <tr> <td>Permanent crop, non-wooded, cropland</td> <td>7</td> </tr> <tr> <td>Annual crop, non-wooded, cropland</td> <td>23</td> </tr> <tr> <td>Grasslands, wooded</td> <td>8</td> </tr> <tr> <td>Grasslands, non-wooded</td> <td>4</td> </tr> <tr> <td>Paramos</td> <td>35</td> </tr> </tbody> </table>	Non-forest land uses	Area-weighted average t C <sub>AGB</sub> ha <sup>-1</sup>	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
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<p><b>QA/QC procedures applied</b></p>																	
<p><b>AGB in primary forest</b></p>	<p>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)<sup>69</sup>:</p> <p><b>Fieldwork organization:</b> 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.</p> <p><b>Fieldwork supervision:</b> During the NFI implementation, the coordinator made field visits to supervise the crews' work. A photographic registry of each plot was made.</p> <p><b>Registry of information:</b> 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.</p> <p><b>Independent evaluation of forest inventory data quality:</b> 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.</p>																

<sup>69</sup> 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-Impronta.pdf>

**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.

<b>Parameters:</b>	<b>Ratio AGB:Percent of canopy cover per forest type (<math>R_c</math>)</b>																		
<b>Description:</b>	<ul style="list-style-type: none"> <li>• <b>Canopy cover and biomass relationship (<math>R_c</math>):</b> For each forest type, a ratio was estimated of aboveground biomass (in t CO<sub>2</sub>e) 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.</li> </ul>																		
<b>Data unit:</b>	Tonnes CO <sub>2</sub> e ha <sup>-1</sup> / % canopy cover																		
<b>Source of Data</b>																			
<b>Introduction</b>	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.																		
<b>Sampling Unit</b>	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 <sup>2</sup> on a rectangular plot of 20 x 50 meters.																		
<b>Selection of Sampling Units</b>	Rodríguez (2018) <sup>70</sup> and Coto (2018) <sup>71</sup> 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; Rodríguez 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%. Rodríguez and Coto used the level 2 systematic grid of SIMOCUTE to complete the plots' sample in these categories.																		
<b>Number of Sampling Units</b>	<p>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:</p> <table border="1" data-bbox="560 1459 1263 1623"> <thead> <tr> <th rowspan="2">Forest Type</th> <th colspan="3">Canopy cover class</th> <th rowspan="2">Total of SU – forest type</th> </tr> <tr> <th>20-49%</th> <th>50-79%</th> <th>80-99%</th> </tr> </thead> <tbody> <tr> <td><i>Wet and Rain Forests</i></td> <td>5</td> <td>5</td> <td>5</td> <td>15</td> </tr> <tr> <td><i>Moist Forests</i></td> <td>12</td> <td>14</td> <td>10</td> <td>36</td> </tr> </tbody> </table>	Forest Type	Canopy cover class			Total of SU – forest type	20-49%	50-79%	80-99%	<i>Wet and Rain Forests</i>	5	5	5	15	<i>Moist Forests</i>	12	14	10	36
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<sup>70</sup> 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>

<sup>71</sup> 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/1svYPJGEoBHpLn72sg4ejpf6uZkp6lIlM/view?usp=sharing>



	<table border="1"> <tr> <td><i>Dry Forests</i></td> <td>8</td> <td>6</td> <td>5</td> <td>19</td> </tr> <tr> <td><i>Mangroves</i></td> <td>5</td> <td>5</td> <td>5</td> <td>15</td> </tr> <tr> <td><i>Palm Forests</i></td> <td>5</td> <td>5</td> <td>5</td> <td>15</td> </tr> <tr> <td><i>Total SU-canopy cover class</i></td> <td>35</td> <td>35</td> <td>30</td> <td>100</td> </tr> </table>	<i>Dry Forests</i>	8	6	5	19	<i>Mangroves</i>	5	5	5	15	<i>Palm Forests</i>	5	5	5	15	<i>Total SU-canopy cover class</i>	35	35	30	100
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<b>Data collection</b>	<p>All trees, shrubs, palms, tree ferns, lianas, and vines with a Diameter at Breast High (DBH) &gt; 10 cm were measured following the protocols of the National Forest Inventory (Ministerio de Ambiente y Recursos Naturales, 2017). The following data were collected:</p> <p><b>Scientific Name:</b> 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.</p> <p><b>Species Code:</b> National Forest Inventory code of the scientific name (genus and species).</p> <p><b>Diameter:</b> registry of diameter in centimeters and at breast height (1.3 m).</p> <p><b>Total height:</b> 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.</p> <p><b>Specific Gravity:</b> the GE values were obtained directly from the Biomass estimation tool developed by SINAC and specialized publications (IPCC, 2003<sup>72</sup>; Myers, 2013<sup>73</sup>; Tree Functional Attributes and Ecological Database, 2018<sup>74</sup>).</p>																				
<b>Data analysis</b>	<p>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<sup>75</sup>). 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.</p>																				
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<i>Mangroves</i>	3.19																				
<i>Palm Forests</i>	4.26																				
<b>QA/QC procedures applied</b>																					
	<p>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):</p>																				

<sup>72</sup> 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.

<sup>73</sup> 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

<sup>74</sup> Tree Functional Attributes and Ecological Database. (2018). Wood Density. Recuperado el 10 de 12 de 2018, de <http://db.worldagroforestry.org/>.

<sup>75</sup> 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)<sup>76</sup>.

**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 $R_c$ (%)
<i>Wet and Rain Forests</i>	16%
<i>Moist Forests</i>	22%
<i>Dry Forests</i>	24%
<i>Mangroves</i>	32%
<i>Palm Forests</i>	37%

<sup>76</sup> 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.

<b>Parameters:</b>	<b>Activity Data of Deforestation (AD<sub>D</sub>) Eq. 5.1</b> <b>Activity Data of Reforestation (AD<sub>R</sub>) Eq. 5.2</b> <b>Forest remaining forests (AD<sub>F-f</sub>) Eq. 5.3</b>
<b>Description:</b>	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
<b>Data unit:</b>	Hectares
<b>Source of data</b>	
<b>Introduction</b>	<p>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, (2020b;2023<sup>77</sup>) prepared the LULC Maps 2019 and 2021 of Costa Rica (MCS 2019/20<sup>78</sup> and MCS 2021/22)<sup>79</sup>, 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).</p> <p>Also, the geodatabase's table of uses, types, and ages of the forest was updated. To automate the workflow, AGRESTA (2015) generated the toolkit <b>REDD tools Costa Rica package</b>. This toolbox runs on the geographic information system QGIS for the Microsoft Windows operating system. The programs were compiled in the QGIS Processing framework<sup>80</sup> allowing to run geoprocessing algorithms implemented in software libraries external to QGIS. The following libraries are used:</p> <ul style="list-style-type: none"> <li>• GRASS GIS (<a href="https://grass.osgeo.org/">https://grass.osgeo.org/</a>)</li> <li>• Orfeo Toolbox (<a href="https://www.orfeo-toolbox.org/">https://www.orfeo-toolbox.org/</a>)</li> <li>• GDAL (<a href="https://gdal.org/">https://gdal.org/</a>)</li> </ul> <p>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<sup>81</sup>. It is important to note that none of these</p>

<sup>77</sup> Córdoba-Peraza, J. (2023). INFORME FINAL MAPA DE COBERTURA Y USO DE LA TIERRA 2021 DE LA SERIE HISTÓRICA DE COSTA RICA SECRETARIA REDD +. Retrieved from <https://drive.google.com/file/d/14pihK3Lqt622Mziv1qF2qz-IB6Ta-RtG/view?usp=sharing>

<sup>78</sup> LULC map 2019 (MCS 2019/20) can be accessed at the following link:  
[https://drive.google.com/drive/folders/1NRxm3yRV6yT1NgLwhp\\_z00wxyA0fpMdx?usp=sharing](https://drive.google.com/drive/folders/1NRxm3yRV6yT1NgLwhp_z00wxyA0fpMdx?usp=sharing)

<sup>79</sup> LULC map 2021 (MCS 2020/21) can be accessed at the following link:  
<https://drive.google.com/drive/folders/19nhF3IXjVpS6EEuGfhCnS-HiQdI4A5RB?usp=sharing>

<sup>80</sup> [https://docs.qgis.org/2.8/en/docs/user\\_manual/processing/](https://docs.qgis.org/2.8/en/docs/user_manual/processing/)

<sup>81</sup> Córdoba-Peraza, J. (2019). Informe final Elaboración del mapa de cobertura y uso de la tierra en Costa Rica 2015. Retrieved from <https://drive.google.com/file/d/14rmbzUdfHL9Zw62PQtbVmbY6blblm79U/view?usp=sharing>

	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 <sup>82,83,84,85</sup> :
<b>Data sources for estimating activity data:</b>	The construction of the AD time series required the following sources of data: <ul style="list-style-type: none"> <li>i. Remotely sensed data from Landsat 8 OLI/TIRS.</li> <li>ii. Mask of the country (in raster format) generated from map MCS 2013/14</li> <li>iii. Land-use maps 2013 and 2015 (MCS 2013/14, MCS 2015/16<sup>86</sup>) 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.</li> <li>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 2019 and 2021.</li> </ul>
<b>Methods for mapping land-use and land-use change</b>	
<b>Selection of images</b>	To prepare the Land-use map 2019 and 2021 (MCS 2019/20 and MCS 2021/22, images from the LANDSAT 8 OLI / TIRS satellite were used for the period from June 2019 to June 2020 for the land-use map of 2019 and from June 2021 to June 2022 for land-use map of 2021. 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). The following bands used were 2, 3, 4, 5, 6, and 7.
<b>Pre-processing and Geometric validation</b>	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 2019/20 and MCS 2021/22 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 2019/20 and MCS 2021/22 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 ( <a href="https://github.com/gersl/fmask">https://github.com/gersl/fmask</a> ) 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.

<sup>82</sup> Córdoba-Peraza, J. (2020). 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](https://drive.google.com/file/d/1WPr46RFOu_1Vr5rAYO_QDUlaL090zWd3/view?usp=sharing)

<sup>83</sup> Córdoba-Peraza, J. (2023). Informe final Elaboración del mapa de cobertura y uso de la tierra en Costa Rica 2021. Retrieved from <https://drive.google.com/file/d/14pihK3Lqt622Mziv1qF2qz-IB6Ta-RtG/view?usp=sharing>

<sup>84</sup> 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/ygiw6zq00a1qtbm/Informe\\_tecnico\\_feb\\_2015.pdf?dl=0](https://www.dropbox.com/s/ygiw6zq00a1qtbm/Informe_tecnico_feb_2015.pdf?dl=0)

<sup>85</sup> 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](https://redd.unfccc.int/files/2016_submission_frel_costa_rica.pdf)

<sup>86</sup> Córdoba-Peraza, J. (2019). Informe final Elaboración del mapa de cobertura y uso de la tierra en Costa Rica 2015. Retrieved from <https://drive.google.com/file/d/15rAwOV9I8jRArkDnVpkf0tyJrYRnu69C/view?usp=sharing>

<b>Radiometric normalization</b>	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.
<b>Random Forest classification</b>	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 2021 (MCS 2021/22) 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.
<b>Postprocessing</b>	Final maps are presented at 30 meters resolution. The preparation of the final maps from the classified images included the following tasks: <ul style="list-style-type: none"> <li>i. The classified images were merged into a mosaic using the classification prioritization algorithm of the "FusionClass" module of REDD tools Costa Rica.</li> <li>ii. Information gaps due to the presence of clouds and shadows, although small, were filled with global data from the Global Forest Change project<sup>87</sup>.</li> <li>iii. MCS 2019/20 and MCS 2021/22 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.</li> <li>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).</li> <li>v. MCS 2019/20 and MCS 2021/22 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.</li> </ul>

<sup>87</sup> 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>.

<b>Activity Data calculation</b>	For calculating the activity data, a cartographic comparison of the wall-to-wall maps MCS 2019/20 and MCS 2021/22 was made to subsequently count the pixel change and stable pixels in the 2019-2021 transition matrix. It was assured that both maps, MCS 2019/20 and MCS 2021/22 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 landuse change was obtained. The stable and converted areas are reported in land-use change matrices in the sheet "LCM 2020-21" of the FREL TOOL CR developed by Carbon Decision International (CDI) to estimate forest emissions for the period.
<b>Value applied in monitoring period</b>	
	<u>2020-2021:</u> <ul style="list-style-type: none"> <li>• Total anthropogenic deforestation: <b>9,305</b> ha</li> <li>• Primary forest anthropogenic deforestation: <b>799</b> ha</li> <li>• Secondary forest and tree plantation anthropogenic deforestation: <b>8,507</b> ha</li> </ul>
<b>QA/QC procedures applied</b>	
<b>Introduction</b>	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:
<b>Download and satellite image preparation</b>	<ol style="list-style-type: none"> <li>1. Verification of file storage errors in digital media that could affect reading the data by the analyst responsible for download support images.</li> <li>2. Previewing and verification of the satellite image quality and metadata by the analyst responsible for downloading support images.</li> <li>3. Previewing and verification of the satellite image quality and metadata by the supervisor (IMN specialist).</li> </ol>
<b>Image orthorectification</b>	Landsat 8 images are already orthorectified, therefore it was not necessary to apply the QA / QC procedure.
<b>Radiometric normalization:</b>	4. Radiometric normalization to reduce the differences between the time-series images.
<b>Generation of cloud and shadow masks</b>	5. The cloud and shadows mask were not validated with checkpoints. Instead, the analysts performed an exhaustive visual inspection.
<b>Land use classification:</b>	<ol style="list-style-type: none"> <li>6. Analysts perform an iterative process of classification, verification of results, error detection, and review of areas and training points.</li> <li>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.</li> <li>8. Visual verification and validation of classified images by comparing them with the available high-resolution image.</li> </ol>
<b>Preparation and validation of land-use maps:</b>	<ol style="list-style-type: none"> <li>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.</li> <li>10. Visual verification of the maps generated after filling the gaps with global data.</li> <li>11. Manual edition of the time-series classification to improve land use mapping, largely aimed at decreasing high classification errors.</li> </ol>
<b>Preparation and validation of land-use change map:</b>	<ol style="list-style-type: none"> <li>12. Visual verification of the country's main deforestation and reforestation areas between consecutive years of the series to detect classification errors.</li> <li>13. Validation of land-use changes between 2019 and 2021 based on photointerpretation of changes on a systematic random grid of points with high-resolution images of the year 2019 and 2021.</li> </ol>
<b>Uncertainty associated with this parameter:</b>	

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 2019/20 – 2021/22 was done following Olofsson et al.'s (2014)<sup>88</sup> guidelines. Reference data were collected by Aguilar, L. (2023)<sup>89</sup>. The following is a summary of the sampling design for the collection of Reference 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 100x100 m square plot with 1 point.

**Number of Sampling Units:** A total of 10,241 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 2019/2020 - 2021/2022 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, 2019, to June 30, 2020) and 2019 (July 1, 2021 to June 30, 2022). In the absence of images of less than 4 m resolution, the Planet images available in the NICFI Program<sup>90</sup> 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 Aguilar, 2023).

**Data collection:** The following procedures were applied during the collection of reference data:

- i. Cold checks: During the data collection process, a certain percentage of randomly selected sample units called "cold checks" are reviewed by a coordinator and data collection operator or group of interpreters. If an interpreter's error is found, the interpreter is directly addressed, and the affected sample units are corrected. Typically, at least 5% of surveyed subplots are reviewed, but in this evaluation, the percentage was increased to 11.0% to improve the remote evaluation process.

<sup>88</sup> Olofsson et al. (2014) Good practices for estimating area and assessing accuracy of land change. *Remote Sensing of Environment* 148, 42-57. <sup>71</sup> 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/1Bcv8qTLH8TGkvbYQpPIGhAJ2xbzIYk8/view?usp=sharing>

<sup>89</sup> Aguilar, L. 2023. Evaluación Visual Multitemporal (EVM) para la determinación de la degradación forestal en los puntos de la malla sistemática de puntos del SIMOCUTE N1 correspondiente al bosque permanente para el periodo 2019-2021 y recolección de datos de cambio de uso de suelo con datos de referencia recolectados mediante EVM con la malla sistemática de puntos del SIMOCUTE N1 sobre imágenes de alta resolución. II Informe. Procedimiento Operativo Estándar. Retrieved from <https://drive.google.com/drive/folders/1AA7GKA--SpT2hxbGMPCsg3QKYOSxVnYT?usp=sharing>

<sup>90</sup> Norway's International Climate and Forests Initiative Imagery Program <https://www.planet.com/nicfi/>

	<p>ii. Hot checks: the supervisor provided immediate feedback to the analysts to improve the interpretations through the weekly review of points. The "hot checks" also contemplate the revision of doubtful classification.</p> <p><b>Data analysis:</b> The Stratified sampling tool for area estimation was used to calculate land-use change areas, developed by FAO Open Foris project and available at <a href="https://github.com/openforis/accuracy-assessment">https://github.com/openforis/accuracy-assessment</a>. The activity data's uncertainty is the bias between the adjusted and estimated areas. The uncertainty values for the monitoring period 2020-2021 are as follows<sup>91</sup>:</p> <p>Uncertainty of hectares of deforestation from 1998-2011: 8%</p> <p>Uncertainty of hectares of non-forest that changed to forest land: 1%</p> <p>Uncertainty of hectares of forests remaining forests in 1998-2011: 3%</p>
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Table 7: Source of Activity Data and description of the methods for developing the data for estimate emissions from degradation during the monitoring period.

<b>Parameters:</b>	<p><b>Activity Data of Degradation (AD<sub>Deg</sub>) Eq 5.4</b></p> <p><b>Activity Data of Permanent Forest Regeneration (AD<sub>E</sub>) Eq. 5.5</b></p>
<b>Description:</b>	<p>Degradation: Hectares of forest with a reduction of canopy cover during the monitoring period.</p> <p>Forest Enhancement: Hectares of forest with an increase of canopy cover during the monitoring period</p>
<b>Data unit:</b>	Hectares
<b>Source of data</b>	
<b>Introduction</b>	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 2019/20 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 (2023) <sup>92</sup> .
<b>Type of sampling</b>	A Systematic Sampling (SYS) over the updated version of Level 1 Systematic Grid with 10,241 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.
<b>Sampling Unit</b>	The Sampling Unit (SU) is a 100x100 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.
<b>Number of Sampling Units</b>	The forest degradation assessment was made on forest lands that remain as forest lands during 2019-2021. 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.

<sup>91</sup> Reference data and uncertainty estimate excel file can be accessed at the following link:

<https://drive.google.com/drive/folders/19vN91oetoPetOxdetRiA0r6PtR-TDDiZ?usp=sharing>

<sup>92</sup> Aguilar, L. 2023. Evaluación Visual Multitemporal (EVM) para la determinación de la degradación forestal en los puntos de la malla sistemática de puntos del SIMOCUTE N1 correspondiente al bosque permanente para el periodo 2019-2021 y recolección de datos de cambio de uso de suelo con datos de referencia recolectados mediante EVM con la malla sistemática de puntos del SIMOCUTE N1 sobre imágenes de alta resolución. II Informe. Procedimiento Operativo Estándar. Retrieved from <https://drive.google.com/drive/folders/1AA7GKA--SpT2hxbGMPCsg3QKYOSxVnYT?usp=sharing>



<b>Classification scheme</b>	<p>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 (&lt;60% forest cover). The following forest cover change classes were assessed by forest type and type of carbon fluxes (anthropogenic and natural):</p> <p>Degradation:</p> <ol style="list-style-type: none"> <li>Intact to Degraded forest</li> <li>Intact to Very degraded forest</li> <li>Degraded to Very degraded forest</li> <li>Very degraded to intact forest</li> <li>Very degraded to degraded forest</li> <li>Degraded to Intact forest</li> </ol> <p>Forest enhancement:</p> <ol style="list-style-type: none"> <li>Very degraded to intact forest</li> <li>Very degraded to degraded forest</li> <li>Degraded to Intact forest</li> </ol> <p>No Condition changes</p> <ol style="list-style-type: none"> <li>Stable intact forest</li> <li>Stable degraded forest</li> <li>Stable very degraded forest</li> </ol>																								
<b>Data Sources</b>	<p>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.</p> <p>Table 8: Data sources and Imagery date range used in the canopy cover evaluation on permanent forest for the monitoring period 2018-2019</p> <table border="1" data-bbox="566 863 1417 1176"> <thead> <tr> <th>Monitoring Year</th> <th>Imagery date range</th> <th>Data sources</th> </tr> </thead> <tbody> <tr> <td>2019</td> <td>July 2019 – June 2020</td> <td rowspan="2"> <ul style="list-style-type: none"> <li>Google Earth dated high-resolution imagery repository (CNES/Airbus, Maxar Technologies)</li> <li>Planet dated imagery of NICFI Program</li> <li>Other sources (Bing Map, Copernicus, Landsat 7, US Geological Survey)</li> </ul> </td> </tr> <tr> <td>2021</td> <td>July 2021 – June 2022</td> </tr> </tbody> </table>	Monitoring Year	Imagery date range	Data sources	2019	July 2019 – June 2020	<ul style="list-style-type: none"> <li>Google Earth dated high-resolution imagery repository (CNES/Airbus, Maxar Technologies)</li> <li>Planet dated imagery of NICFI Program</li> <li>Other sources (Bing Map, Copernicus, Landsat 7, US Geological Survey)</li> </ul>	2021	July 2021 – June 2022																
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2021	July 2021 – June 2022																								
<b>Interpretation Key</b>	<p>The Version 1.2. 2018. SIMOCUTE land cover class key was used to determine canopy cover:</p> <p>Table 9: Land cover key used in the land cover evaluation protocol for the years 2018, and 2019.</p> <table border="1" data-bbox="761 1375 1159 1833"> <thead> <tr> <th>Code</th> <th>Land cover class</th> </tr> </thead> <tbody> <tr><td>1100</td><td>Trees</td></tr> <tr><td>1200</td><td>Shrubs</td></tr> <tr><td>1300</td><td>Herbaceous</td></tr> <tr><td>1400</td><td>Palm</td></tr> <tr><td>Not included</td><td>Bromeliads</td></tr> <tr><td>1500-1600</td><td>Greenhouse</td></tr> <tr><td>1700</td><td>Other vegetation</td></tr> <tr><td>2000-2200</td><td>No vegetation</td></tr> <tr><td>3000</td><td>Water</td></tr> <tr><td>4000</td><td>Clouds and shadows</td></tr> <tr><td>5000</td><td>Not classifiable</td></tr> </tbody> </table>	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
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<b>Data collection</b>	See QA/QC procedures.																								

<p><b>Data analysis</b></p>	<p>The country developed a tool for calculating emissions and removals on permanent forest lands ("Herramienta_degradación.xlsx"<sup>93</sup>). The database for the visual interpretation of canopy cover for the periods 2016-2018, 2018-2019, 2019-2021 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 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 2019-2021. 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.</p>
<p><b>Value applied in monitoring period:</b></p>	
	<ul style="list-style-type: none"> <li>• <b>2,193,917</b> hectares of forests remaining forests in the monitoring period (2019-2021)</li> <li>• <b>58,700</b> hectares of anthropogenic degradation (2019-2021)</li> <li>• <b>48,540</b> hectares of anthropogenic forest enhancement (2019-2021)</li> </ul>
<p><b>QA/QC procedures applied</b></p>	
	<p>Aguilar (2023) 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:</p> <p><b>Consideration of spatial and temporal context:</b> The protocol includes a procedure for canopy cover change interpretation considering the spatial and temporal context.</p> <p><b>Reference order of the repositories of images:</b> 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, if the monitoring period images are equal or better quality than the 2019 assessment.</p> <p><b>Data registry forms:</b> The canopy cover change information was recorded in standard Collect Earth Desktop forms.</p> <p><b>Training:</b> The supervisor trained the interpreters before starting the interpretation of plots to calibrate and leave clear procedures to collect the most accurate information possible.</p> <p><b>Supervision of interpreters ("Hot Checks"):</b> The supervisor opened remote sessions between the coordinator and the interpreter; 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.</p> <p><b>Checking of interpretations by the supervisor, without interpreters' presence ("Cold Checks"):</b> During the data collection process, a certain percentage of randomly selected sample units called "cold checks" are reviewed by a coordinator and data collection operator or group of interpreters. If an interpreter's error is found, the interpreter is directly addressed, and the affected sample units are corrected. Typically, at least 5% of surveyed subplots are reviewed, but in this evaluation, the percentage was increased to 11.0% to improve the remote evaluation process.</p> <p><b>Checking of interpreters' consistency ("Blind Checks"):</b> 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.</p> <p><b>Consistency between reference and monitoring period data:</b> The analyst reviewed the consistency of 2021 canopy cover data with the 2019 evaluation.</p>

<sup>93</sup> Degradation tool can be accessed in the following link:

[https://docs.google.com/spreadsheets/d/11r7J0a6BHZx5aWyzC45UatWY3XAlnfp0?rtpof=true&usp=drive\\_fs](https://docs.google.com/spreadsheets/d/11r7J0a6BHZx5aWyzC45UatWY3XAlnfp0?rtpof=true&usp=drive_fs)

**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 2019-2021 vary depending on the forest type and the conversion class. It is based on the sampling error.

**Description of error found in degradation tool:**

The estimate of degradation is made with 4377 sampling plots, as shown in column B of the "Degradation tool". The canopy cover change is collected with Collect Earth Desktop (CED) and imported to the Degradation tool for emission calculations.

The information collected from CED and the quality control processes applied have been well maintained. However, an inconsistency was found in the canopy cover data loaded into the tool in Excel: "Degradation tool" for the periods 2016-2018, 2018-2019, and 2019-2021.

This inconsistency was detected by an additional review that was carried out, given a considerable increase in the results of the degradation analysis in the period 2019-2021. The statistics of illegal logging events did not explain this increase in emissions from degradation, nor were there no changes in SINAC's budget for illegal logging control.

The error occurred during importing canopy cover data from the files generated in CED to the "Degradation Tool". A human error was committed entering plot number **7948**, which is not part of the original 4377 plots to be evaluated. In addition, plot 14764 was omitted, even though it was collected in the CED form. This error generated the plot's order change for monitoring periods after the 2016 assessment.

To fix this error, we entered the data corresponding to the omitted plot (14764), plot number 7948 was eliminated, and the information of all the plots for the 2 previous periods was ordered according to the plot number of column B of the "Degradation tool ". In addition, it was confirmed that the data collected from CED for the year 2021 was imported in the right order into the "Degradation Tool."

The QA/QC procedures have been updated for collecting canopy cover changes in CED and the emissions calculation. To avoid this type of error, the Collect Earth Desktop form now includes the entire time series canopy cover data, and the dataset import is made including the complete time series instead of annexing the last period only. Furthermore, when a point of degradation is found, it will be discussed in a group and documented.

## 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 compared to the estimates provided in the most recent ER Program Document is presented in detail in the first ER-MR Annex 4<sup>94</sup>.

Year of Monitoring / Reporting period t	Average annual historical emissions from deforestation over the Reference Period (tCO <sub>2-e</sub> /yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO <sub>2-e</sub> /yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO <sub>2-e</sub> /yr)	Adjustment, if applicable (tCO <sub>2-e</sub> /yr)	Reference level (tCO <sub>2-e</sub> /yr)
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
<b>Total</b>	<b>11,971,589</b>	<b>2,767,948</b>	<b>-9,568,102</b>	<b>NA</b>	<b>5,171,435</b>

<sup>94</sup> The final version of Costa Rica First ER Monitoring Report can be Access at the following link: [https://www.forestcarbonpartnership.org/system/files/documents/costa\\_rica\\_fcpf\\_er\\_monitoring\\_report\\_1st\\_rp\\_final\\_0.pdf](https://www.forestcarbonpartnership.org/system/files/documents/costa_rica_fcpf_er_monitoring_report_1st_rp_final_0.pdf)

## 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:

$$RL_{RP} = \frac{\sum_{t=1}^{RP} ER_{RA,t}}{RP} = \frac{\sum_{t=1}^{RP} \sum_{i=1}^l (AD_{RAi,t} * EF_{RAi,t})}{RP}$$

Equation 2

Where:

ER <sub>RA,t</sub>	=	Emissions or removals associated to REDD+ activity RA in year t; tCO <sub>2-e</sub> yr <sup>-1</sup>
AD <sub>RAi,t</sub>	=	AD associated to REDD+ activity RA for the land use transition i in year t; ha yr <sup>-1</sup>
EF <sub>RAi,t</sub>	=	EF associated to REDD+ activity RA applicable to the land use transition i in year t; tCO <sub>2-e</sub> ha <sup>-1</sup>
RP	=	Reference Period in years
i	=	A land use transition represented in a cell of the land use change matrix; dimensionless
l	=	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<sup>95</sup>. The country also prepared an Emission Reduction Calculation Tool based on the FREL and Degradation tool results<sup>96</sup>.

Year of Monitoring / Reporting Period	Emissions from deforestation (tCO <sub>2e</sub> /yr)	If applicable, emissions from forest degradation (tCO <sub>2-e</sub> /yr)*	If applicable, removals by sinks (tCO <sub>2-e</sub> /yr)	Net emissions and removals (tCO <sub>2-e</sub> /yr)
2020	542,797	2,764,822	-5,793,491	-2,485,873
2021	574,858	2,764,822	-5,624,483	-2,284,803
<b>Total</b>	<b>1,117,655</b>	<b>5,529,643</b>	<b>-11,417,974</b>	<b>-4,770,676</b>

<sup>95</sup> FREL and Degradation TOOL can be accessed in the following links:

FREL: [https://docs.google.com/spreadsheets/d/103iZDLVaK3bKC-OQwBV4CmSYj\\_sS25nh/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/103iZDLVaK3bKC-OQwBV4CmSYj_sS25nh/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true)

Degradation:

<https://docs.google.com/spreadsheets/d/11r7J0a6BHZx5aWyzC45UatWy3XAInfp0/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true>

<sup>96</sup> Emission Reduction Calculation tool can be accessed in the following link:

<https://docs.google.com/spreadsheets/d/17ivM7Lgv22C7myLo31gwIJSevKLYdtII/edit?usp=sharing&ouid=101528572552038951719&rtpof=true&sd=true>

### 4.3 Calculation of emission reductions

<b>Total Reference Level emissions during the Reporting Period (tCO<sub>2</sub>-e)</b>	5,171,435
<b>Net emissions and removals under the ER Program during the Reporting Period (tCO<sub>2</sub>-e)</b>	-4,770,676
<b>Emission Reductions during the Reporting Period (tCO<sub>2</sub>-e)</b>	9,942,111

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## 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?
<b>Activity Data</b>					
Measurement	Systematic and random	<p><b>Land-use change areas (deforestation, reforestation and forest remaining forest areas):</b> 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.</p> <p>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.</p> <p>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</p>	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?
		<p>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.</p> <p>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.</p>			
Measurement	Systematic and random	<p><b>Permanent forest degradation and regeneration:</b> 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:</p> <ol style="list-style-type: none"> <li>i. <b>Consideration of spatial and temporal context:</b> The protocol includes a procedure for canopy cover change interpretation considering the spatial and temporal context (see section 1.6 in Aguilar, 2020).</li> <li>ii. <b>Reference order of the repositories of images:</b> 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, if the monitoring period images are equal or better quality than the 2017 assessment.</li> <li>iii. <b>Data registry forms:</b> The canopy cover change information was recorded in standard Collect Earth Desktop forms (see section 1.7 in Aguilar, 2020).</li> <li>iv. <b>Training:</b> The supervisor trained the interpreters before starting the interpretation of plots to calibrate and leave clear procedures to collect the most accurate information possible.</li> <li>iv. <b>Supervision of interpreters ("Hot Checks"):</b> 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</li> </ol>	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?
		<p>all interpreters to improve the group of interpreters' criteria. The supervisor resolved the consultations of the interpreters online.</p> <p>v. <b>Checking of interpretations by the supervisor, without interpreters' presence ("Cold Checks"):</b> 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.</p> <p>vi. <b>Checking of interpreters' consistency ("Blind Checks"):</b> 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. <b>Consistency between reference and monitoring period data:</b> The analyst reviewed the consistency of 2018 canopy cover data with the 2016 evaluation performed by OrtizMalavassi (2017).</p> <p>vii. <b>Treatment of plots with forest cover less than 30%:</b> 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 revisited 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 and 2019-2021.</p> <p>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.</p>			
Representativeness	Systematic	<p><b>Land-use change areas (deforestation, reforestation, and forest remaining forest areas):</b> 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.</p>	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?
		<p>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.</p> <p><b>Permanent forest degradation and regeneration:</b> High-resolution imagery used to estimate degradation and regeneration were selected from June to June for the year under monitoring.</p>			
Sampling	Random	<p><b>Land-use change areas (deforestation, reforestation, and forest remaining forest areas):</b> 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, MCS 2019/20, and MCS 2021/22 was done following Olofsson et al.'s (2014)<sup>97</sup> 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.</p>	Low	Yes	Yes

<sup>97</sup> 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	<b>Permanent forest degradation and regeneration:</b> 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
<b>Emission Factor</b>					
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					
Wood density estimation	Systematic and Random	The wood density values were obtained directly from specialized publications (Biomass estimation tool developed by SINAC, IPCC 2003 <sup>98</sup> ; Myers 2013 <sup>99</sup> ; Tree Functional Attributes and Ecological Database, 2018 <sup>100</sup> ). 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

<sup>98</sup> 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.

<sup>99</sup> 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

<sup>100</sup> Tree Functional Attributes and Ecological Database. (2018). Wood Density. Recuperado el 10 de 12 de 2018, de <http://db.worldagroforestry.org/>.

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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?
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) <sup>101</sup> . 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 ratios or carbon fraction.	Low	No	No
Representativeness	NA	This source of uncertainty is not applicable. Costa Rica generates estimates of carbon stocks per forest type.	NA	NA	NA
<b>Integration</b>					
Model	Systematic	Manuals have been prepared for the correct use of FREL and Degradation tools <sup>102</sup> , 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

<sup>101</sup> 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.

<sup>102</sup> The manual of FREL Tool can be accessed in the following link: <https://drive.google.com/file/d/1NuL5Jld7nKVsAf7mRsEepm2n8WRVpT/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	9,305 ha in 2020 and 2021	Sampling error	Truncated normal	Minimum value assumed to be 0
Area (hectares) of forests remaining	2,194,364 ha in 2020 and 2,193,917 ha in 2021	Sampling error	Truncated normal	Minimum value assumed to be 0
Area (hectares) of new forests	918,763 ha in 2020 and 916,368 in 2021	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<sup>103</sup>.

		Reporting Period	Crediting Period
		Total Emission Reductions*	Total Emission Reductions*
<b>A</b>	<b>Median</b>	9,312,211	19,112,161
<b>B</b>	<b>Upper bound 90% CI (Percentile 0.95)</b>	15,853,036	31,680,042
<b>C</b>	<b>Lower bound 90% CI (Percentile 0.05)</b>	3,399,246	7,824,276
<b>D</b>	<b>Half Width Confidence Interval at 90% (B – C / 2)</b>	6,226,895	11,927,883
<b>E</b>	<b>Relative margin (D / A)</b>	66.9%	62.41%
<b>F</b>	<b>Uncertainty discount</b>	12%	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<sup>104</sup>.

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

<sup>103</sup> MC propagation analyses to estimate uncertainty of Emission Reductions can be found in the following link:

<https://docs.google.com/spreadsheets/d/12NZpls3RI4UrTydeOMTZkVg3ao38IFg7/edit?usp=sharing&oid=101528572552038951719&rtpof=true&sd=true>

<sup>104</sup> Sensitivity analyses of the uncertainty estimate for Emission Reductions can be found in the following link:

<https://drive.google.com/drive/folders/1sPiBD5kj8JN6vXvLb6LaaTUjdRh8VtT?usp=sharing>



<b>Mapping error (AD) of new forests in the monitoring period</b>	64.0%	0.5% increase
<b>Carbon stocks used to estimate enhancements in new forests</b>	62.3%	2.1% decrease
<b>Mapping error (AD) of forests remaining forests in the reference period</b>	63.7%	0.2% increase
<b>Mapping error (AD) of forests remaining forests in the monitoring period</b>	63.9%	0.4% increase
<b>Changes in canopy cover in forests remaining forests in the reference period</b>	63.2%	0.6% decrease
<b>Changes in canopy cover in forests remaining forests in the monitoring period</b>	59.7%	6.2% decrease
<b>Ratio of aboveground biomass (in t CO2e) to % canopy cover</b>	59.3%	6.8% decrease
<b>Carbon stocks used to estimate enhancements in forests remaining forests</b>	63.7%	0.2% increase

## 6 TRANSFER OF TITLE TO ERS

### 6.1 Ability to transfer title

According to Benefit Sharing Plan, FONAFIFO will distribute direct payments or monetary benefits from the Emissions Reduction Purchase Agreements (ERPA) to forest landowners. 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<sup>105</sup>. The landowners need a Forest Emissions Reduction Agreement (its acronym in Spanish is CREF) duly signed with FONAFIFO to participate in the ER-Program. The amount of compensation for forest owners is fixed and will depend on forest area contribution contributing to forest emissions reduction.

The ER-Program has experienced significant challenges in documenting ownership of emissions reduction. During the first phase of field visits for the geolocation of properties, the potential participants showed no interest due to the initial possible payment (US\$7/ha per year). This first estimate of emission reduction compensation was unattractive for the landowners compared with the current PES amount (US\$64/ha per year). To address this issue, the CREF payment has been raised to US\$18 per hectare annually. This increase in funds comes from the REDD+ result-based payment obtained from the Green Climate Fund for 2014-2015 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 sought ways to involve unregistered farms, which make up a significant portion of ownership and farm size. In August 2022, Executive Decree N 43649-MINAE was released<sup>106</sup>, allowing forest holders in Protected Areas to join the ER Program (CREF) and the Payment for Environmental Services Program. This positively affected the ER Program's recruitment level and increased the volume of work to review legal and technical requirements. The unregistered farms are the ones that generate the greatest volume of work, given the number of requirements established in the procedure's manual and in the Eco-Markets law (8640) that establishes the legal conditions for holders.

The Secretariat has completed the second version of the global geodatabase of non-overlapped forest land. Table 11 summarizes forest area by forest owner type by year; of forest land resulted eligible to participate in the Emission Reduction Program of Costa Rica. The recruitment process will be open until November 2024. The final figure of Forest Area included in the ER Program during the first and second monitoring reports will be defined in December 2023. More information on the legal basis of the ER transfer title will be provided once it becomes available.

The REDD+ Secretary started the implementation of 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<sub>2</sub>eq) in emissions during the 2014-2015 period<sup>107</sup>. 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.

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<sup>105</sup> Manual of Requirements and Procedures for the Emissions Reduction Program can be accessed at the following link [https://www.imprentanacional.go.cr/pub/2022/09/16/ALCA197\\_16\\_09\\_2022.pdf](https://www.imprentanacional.go.cr/pub/2022/09/16/ALCA197_16_09_2022.pdf) (Page 14)

<sup>106</sup> Executive Decree N 43649-MINAE can be accessed at following link <https://onfcr.org/wp-content/uploads/MODIF-PSA-publicado-en-La-Gaceta-165-31-Ago-22.pdf> (Page 11)

<sup>107</sup> FP144 Costa Rica REDD-plus Results-Based Payments for 2014 and 2015 <https://www.greenclimate.fund/project/fp144>

- iii. **Engagement of Forestry Organizations:** The principal forest owner organizations were contacted, seeking their partners' involvement.
- iv. **New call for participation:** a new call was made in August 2021 to explain the ER Program and invite forest owners to participate.

Table 11. Forest area identified until May 2023 as eligible to participate in the Emission Reduction Program of Costa Rica.

		Forest Cover Owner Type	2018 (ha)	2019 (ha)	2020 (ha)	2021 (ha)
Reported on Substantial Volume of ER	1	CREF beneficiaries who have either registered or non-registered properties	29,928	29,948	29,848	29,652
		With signed contracts or have been approved for signing.				
		Legal and technical analysis in process	27,038	26,981	26,792	26,608
		Geo-referencing process of the beneficiary's property	26,553	26,553	26,553	26,553
	2	Indigenous Territories	179,165	179,408	175,269	175,268
	3	FONAFIFO PES Program	394,839	403,510	420,410	373,975
Biodiversity Fund		6,285	7,536	8,657	9,197	
4	State Natural Heritage-SINAC	652,551	652,362	652,215	652,151	
<b>Subtotal</b>			<b>1,316,360</b>	<b>1,326,299</b>	<b>1,339,744</b>	<b>1,293,404</b>
Non-reported areas on Substantial Volumes of ERs. Areas under legal analysis.	4	State Natural Heritage - JAPDEVA	73,274	73,324	73,122	72,787
		State Natural Heritage Local Governments	243	243	243	243
		SNH-Other State Institutions	6,238	6,237	6,237	6,077
	5	Forest cover in inalienable areas	38,715	40,227	39,076	38,740
	6	Forest cover in Protected Wilderness Areas (outside National Parks, Biological Reserves, and National Monuments)	324,201	321,316	319,180	332,255
	7	Forest Cover in Overlay Analysis	1,673	1,747	2,516	2,533
	8	Forest owners NOT ELIGIBLE for the RE program	2,597	2,512	2,511	2,624
<b>Subtotal</b>			<b>1,763,300</b>	<b>1,771,905</b>	<b>1,782,630</b>	<b>1,748,663</b>
<b>Subtotal Forest Area with documented ownership:</b>			<b>1,316,360</b>	<b>1,326,299</b>	<b>1,339,744</b>	<b>1,293,404</b>
<b>Forest Cover Area without documented ownership:</b>			<b>446,941</b>	<b>445,607</b>	<b>442,886</b>	<b>455,259</b>
<b>Total area of forest cover:</b>			<b>3,116,835</b>	<b>3,116,835</b>	<b>3,110,285</b>	<b>3,110,285</b>
<b>Percentage of REs able to transfer the Title to the REs:</b>			<b>42.2%</b>	<b>42.6%</b>	<b>43.1%</b>	<b>41.6%</b>
<b>Total emissions reduced (TCO2eq):</b>			<b>1,745,413</b>	<b>1,745,413</b>	<b>1,666,552</b>	<b>1,666,552</b>
<b>Minimum number of ERs contracted for the reporting period (TCO2eq):</b>			<b>1,700,000</b>	<b>1,700,000</b>	<b>1,700,000</b>	<b>1,700,000</b>
<b>ER payment (US\$)</b>			<b>\$8,727,066</b>	<b>\$8,727,066</b>	<b>\$8,332,758</b>	<b>\$8,332,758</b>

**Note:** ERs are calculated according to the Carbon Pools and the Reference Level described in the Annex 4 of the ER Monitoring Report submitted to the Carbon Fund of the FCPF.

([https://www.forestcarbonpartnership.org/system/files/documents/costa\\_rica\\_fcpf\\_er\\_monitoring\\_report\\_1st\\_rp\\_final\\_0.pdf](https://www.forestcarbonpartnership.org/system/files/documents/costa_rica_fcpf_er_monitoring_report_1st_rp_final_0.pdf)).

**Source:** You can access annual summaries (2018, 2019, 2020, 2021) of eligible areas in both geo-database and Excel file formats by clicking on the link below: <https://drive.google.com/drive/folders/15xJaOxPB2bjhAoLWx5RY1vehF4d88uVv?usp=sharing>

## 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). SINAMECC 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<sup>108</sup>. The system operates as a sub-module of the National Environmental Information System (SINIA), linked to the National Statistical System (SINIA). Climate Change Directorate (DCC) of the Ministry of Environment and Energy (MINAE) coordinates SINAMECC<sup>109</sup>. 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)<sup>90</sup>.

SINAMECC 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<sup>110</sup>.

The REDD+ Secretariat has completed the documentation forms required by the SINAMECC Mitigation Actions Registry for the Costa Rica Emission Reduction Program (PRE)<sup>111</sup>. This template includes the following information, among others (MF I.37.2): i. Initiative Name, ii. Entity promoting the initiative (name, business name, representative, 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

<sup>108</sup> 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](http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?nValor1=1&nValor2=86584)

<sup>109</sup> 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](http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?nValor1=1&nValor2=66973) <sup>90</sup>  
<http://sinamecc.go.cr/acerca-de>

<sup>110</sup> 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>

<sup>111</sup> 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=tru](https://docs.google.com/spreadsheets/d/1lTs_8NvZef79ZfqAVrTVcltq2_UB88GB/edit?usp=sharing&ouid=101528572552038951719&rtpof=tru)

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<sup>112</sup>.

The REDD+ Secretariat is implementing the ER-Program Data Management System (DMS). The ER Program's DMS includes i. The entity that has Title to ERs produced; ii. Geographical boundaries of the State Natural Heritage (National Parks, National Monuments and Biological Reserves, inalienable areas), Indigenous Territories, and Private Owned Forest Properties; iii. Scope of REDD+ activities. The DMS system produces the input information included in Table 11, with ERs produced by owner type and year according to the Carbon Pools and the Reference Level described in Annex 4 of the ER Monitoring Report submitted to the Carbon Fund of the FCPF.

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<sup>113</sup> on FONAFIFO's website<sup>114</sup>. 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 built a geospatial database with the potential ER Program beneficiaries, including private forest owners, Indigenous peoples, SINAC, FONAFIFO, and other institutions administering State Natural Heritage.
- *Property geolocation analysis*: The database allows REDD+ Secretariat to locate overlapped 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 received during the calls. The procedure for the overlay analysis is in the manual of requirements and procedures for the Emissions Reduction Program<sup>115</sup>.
- *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 more than 150 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.

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<sup>112</sup> 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&oid=101528572552038951719&rtpof=true&sd=true](https://docs.google.com/document/d/1ckHxhAomfagRVMfN9OH_86nOcx06VEIE/edit?usp=sharing&oid=101528572552038951719&rtpof=true&sd=true)

<sup>113</sup> Application to Join the CREF Project

<https://forms.office.com/Pages/ResponsePage.aspx?id=ytnVe7YiPUK3Aloh1bsHR3mtNt1gTYhOgux9YcGhPN9UNkRVT1NFMdZES0FMROdEVTRXSTMwQ0kzWC4u>

<sup>114</sup> [www.ganacontubosque.com](http://www.ganacontubosque.com)

<sup>115</sup> 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&oid=101528572552038951719&rtpof=true](https://docs.google.com/document/d/1ckHxhAomfagRVMfN9OH_86nOcx06VEIE/edit?usp=sharing&oid=101528572552038951719&rtpof=true)

The REDD+ Secretariat, with the support of the World Bank, built a repository system for Costa Rica REDD+ information. This repository is 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.

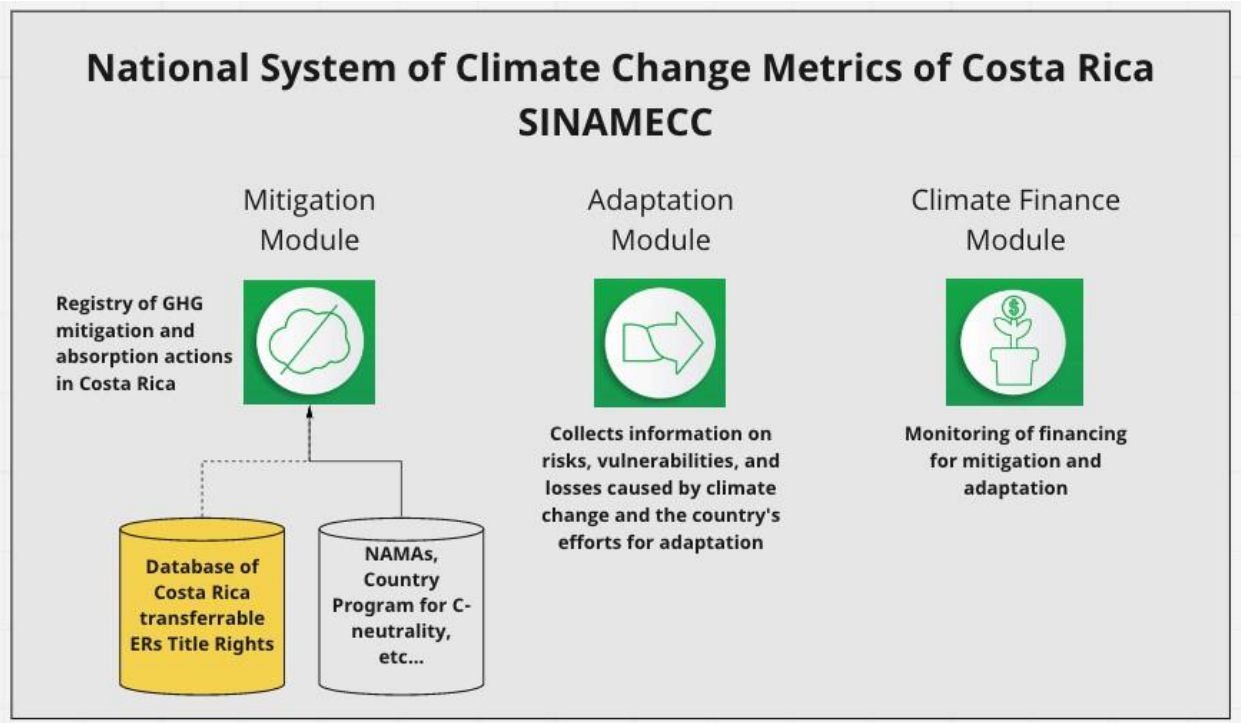


Figure 3: National System of Climate Change Metrics of Costa Rica (SINAMECC). Costa Rica Emission Reduction Program's data management system is part of the SINAMECC. This system is Costa Rica's official platform to coordinate climate information in the country.

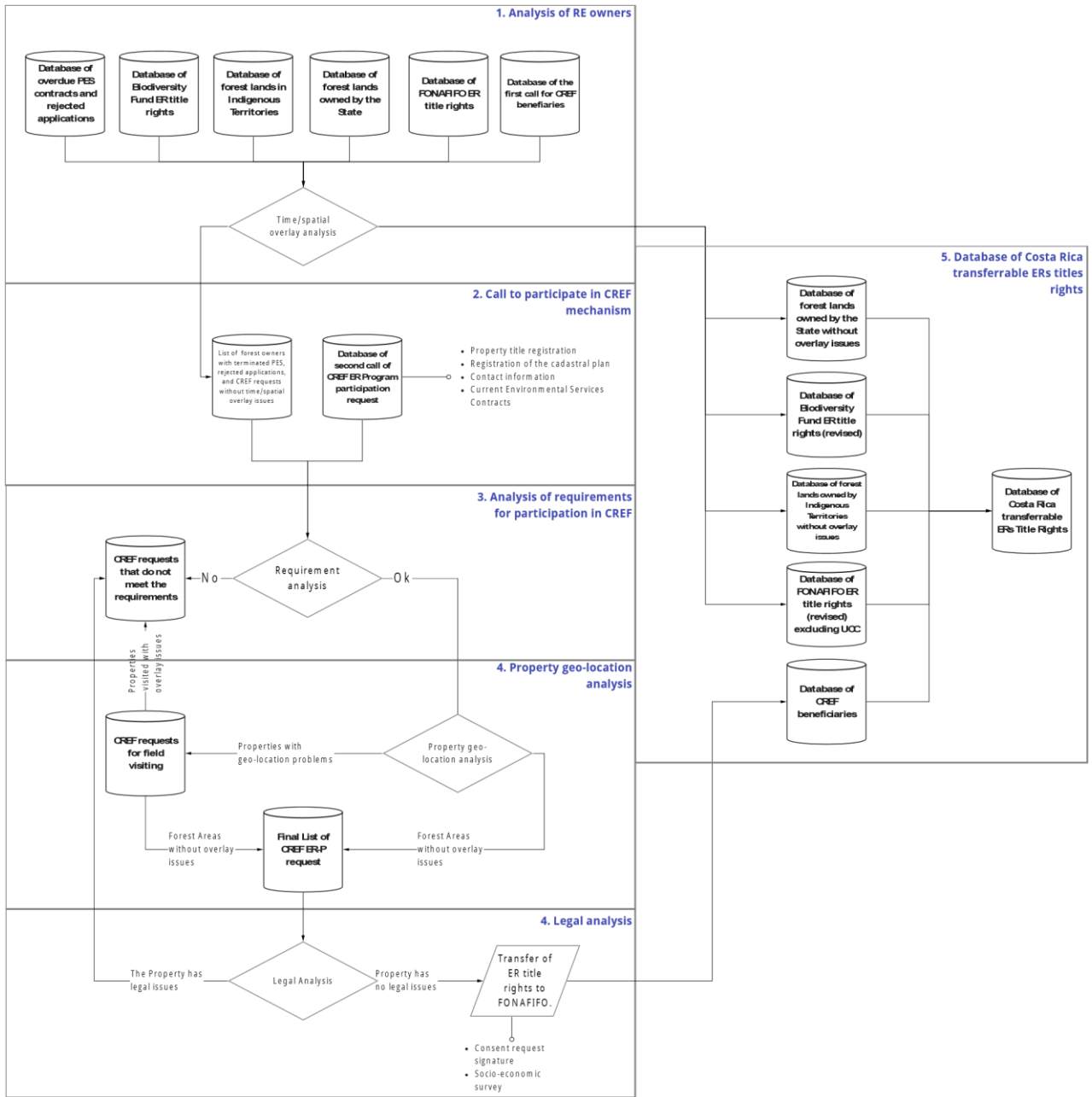


Figure 4: Line diagram for the building process of Costa Rica ER-Program Data Management System



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 first and second reporting period, and Costa Rica reduced net emissions by 19,112,161 t CO<sub>2</sub>e during the crediting period (see table in section 5.2).

### 7.2 Quantification of Reversals during the Reporting Period

Intentionally left blank. No reversals occurred during the reporting period.

<b>A.</b>	<b>ER Program Reference level for this Reporting Period (tCO<sub>2</sub>-e)</b>	<i>from section 4.1</i>	
<b>B.</b>	<b>ER Program Reference level for all previous Reporting Periods in the ERPA (tCO<sub>2</sub>-e).</b>	<i>from previous ER Monitoring Reports</i>	
<b>C.</b>	<b>Cumulative Reference Level Emissions for all Reporting Periods [A + B]</b>		+

**D.** Estimation of emissions by sources and removals by sinks for this Reporting Period (tCO<sub>2</sub>-e) *from section 4.2*

**E.** Estimation of emissions by sources and removals by sinks for all previous Reporting Periods in the ERPA (tCO<sub>2</sub>-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  $[J / H \times (H - G)]$

### 7.3 Reversal risk assessment

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk setaside percentage
Default risk	N/A	10%	N/A	10%
Lack of broad and sustained stakeholder support	<p>Land tenure conflicts, carbon rights conflicts, insufficient stakeholder consultation.</p> <p>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</p>	10%	Reversal Risk is considered low: 10% discount	0%
	<p>adopting improved governance structures and processes<sup>116</sup> 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.</p> <p>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.</p> <p>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).</p>			

<sup>116</sup> 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.

<p><b>Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination</b></p>	<p>Insufficient experience implementing programs and policies, lack of cross-sectoral cooperation and between gov. levels.</p> <p>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.</p>	<p><b>10%</b></p>	<p><i>Reversal Risk is considered low: 10% discount</i></p>	<p>0%</p>
<p><b>Lack of long-term effectiveness in addressing underlying drivers</b></p>	<p>Limited decoupling of deforestation and degradation from economic activities, lack of laws and regulations conducive to REDD+ objectives.</p> <p>Costa Rica has developed a REDD+ Strategy Implementation Plan<sup>117</sup> 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.</p>	<p><b>5%</b></p>	<p><i>Reversal Risk is considered low: 5% discount</i></p>	<p>0%</p>
<p><b>Exposure and vulnerability to natural disturbances</b></p>	<p>Exposure and vulnerability to natural disturbances and disasters, limited capacity and/or experience in preventing them.</p>	<p><b>5%</b></p>	<p><i>Reversal Risk is considered</i></p>	<p>0%</p>

<sup>117</sup> Plan de Implementación de la Estrategia Nacional REDD+ Costa Rica. 2017. Versión 7. 57 pp.

	<p>Costa Rica considers the following natural risks affecting its forest lands:</p> <ul style="list-style-type: none"> <li>• 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 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.</li> <li>• 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.</li> </ul>		<i>low: 5% discount</i>	
			<b>Total reversal risk set-aside percentage</b>	10%
			<b>Total reversal risk set-aside percentage from ER-PD or previous monitoring report (whichever is more recent)</b>	10%

## 8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

A.	Emission Reductions during the Reporting period (tCO <sub>2</sub> -e)	<i>from section 4.3</i>	9,942,111
B.	If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)		0
C.	Number of Emission Reductions estimated using measurement approaches (A-B)		9,942,111
D.	Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested	<i>from section 6.1</i>	42%
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	<i>from section 6.4</i>	0
F.	Total ERs (B+C)*D-E		4,208,464
G.	Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period	<i>from section 5.2</i>	12%
H.	Quantity of ERs to be allocated to the Uncertainty Reversal Buffer (0.15*B/A*F)+(G*C/A*F)		505,016
I.		<i>from section</i>	10%

	<b>Total reversal risk set-aside percentage applied to the ER program</b>	7.3	
J.	<b>Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)</b>		185,172
K.	<b>Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*5%</b>		185,172
L.	<b>Number of FCPF ERs (F- H – J – K)</b>		3,333,103 <sup>118</sup>

<sup>118</sup> 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 in December, 2023.



## **ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS**

## **ANNEX 2: INFORMATION ON THE IMPLEMENTATION OF THE BENEFITSHARING PLAN**

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