Forest Carbon Partnership Facility (FCPF)
Carbon Fund

ER Monitoring Report (ER-MR)

ER Program Name and Country:	Payment for emission reductions project around the Taï National Park
Reporting Period covered in this report:	30-10-2020 to 31-12-2021
Number of FCPF ERs:	**7,107,404.09**
Quantity of ERs allocated to the Uncertainty Buffer:	384,599.79
Quantity of ERs to allocated to the Reversal Buffer:	1,661,471.09
Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:	461,519.75
Date of Submission:	03-04-2023
Version	V 1.0

Notice: Annex 1, 2, and 3 are not included in this version since they are being completed by the Program Entity. The full Report will be made available as soon as Annex 1, 2, and 3 are completed and the validation/verification are concluded as outlined in the FCPF Process Guidelines.

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ACRONYMS AND ABBREVIATIONS

AFOLU	Agriculture Forestry and Other Land Use
AD	Activity Data
AFOR	Rural Land Agency
AGB	Above-ground Biomass
AIC	Akaike Information Criterion
ANDE	Environment National Agency
BFAST	Breaks for Additive Season and Trend
BGB	Below Ground Biomass
BNETD	National Office for Technical Studies and Development
C2D	Debt Reduction and Development Contract
CAP	Community Action Plan
CCDC	Continuous Change Detection and Classification
CF	Classified Forest
CFI	Cocoa and Forests Initiative
CH_4	Methane
CI	Confidence Interval
CIGN	Geospatial and Digital Information Center
CMC	Complaints Management Committee
CMM	Complaint Management Mechanism
CNF	National Floristic Center
CNTIG	National Committee for Remote Sensing and Geographic Information
CO_2	carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSOs	Civil society Organization
CSRS	Swiss Center for Scientific Research
CURAT	University Center for Research and Application in Remote Sensing
DBH	Diameter at Breast Height
DGM	Dedicated Grant Mechanism
EDF	European Development Fund
EF	Emission Factors
ERP	Emission Reduction Program
ERPA	Emission Reductions Payment Agreement
ERPD	Emissions Reduction Program Document
ESA	European Space Agency
ESRI	Environmental Systems Research Institute
EU	European Union
FAO	Food and Agriculture Organization of the United Nations

FCPF	Forest Carbon Partnership Facility
FGRM	Feedback and Grievance Redress Mechanism
FIP	Forest Investment Project
FL	Forest Land
FMT	Facility Management Team
FPRCI	Foundation for Parks and Reserves of Côte d'Ivoire
FREL	Forest Reference Emission Level
FRL	Forest Reference Levels
GCF	Green Climate Fund
CIGN	Geographic and Digital Information Center
GFC	Global Forest Change
GHG	Greenhouse Gas
GPS	Global Positioning System
GRM	Grievance and Redress Mechanism
IFFN	National Wildlife Forest Inventory
IGN-FI	National Institute of Geographical and Forestry Information France International
IGT	Institute of Tropical Geography
INPHB	Félix Houphouët-Boigny National Polytechnic Institute
IPCC	Intergovernmental Panel on Climate Change
ISLA	Initiative for sustainable Land Use
M&E	Monitoring & Evaluation
MEF	Ministry of Economy and Finance
MEMINADER	Ministry of State Ministry of Agriculture and Rural Development
MINEDD	Ministry of the Environment and Sustainable Development
MINEF	Ministry of Waters and Forests
MRV	Measurement, Reporting and Verification
N_2O	Protoxide nitrogen
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NGO	Non- Governmental Organization
OIPR	Ivorian Office of Parks and Reserves
OL	Other Lands
PAD	Project Appraisal Document
PCRMF	Physical Cultural Resource Management Framework
PES	Payment for Environmental Services
PESM	Prescription of Environmental and Social Measures
PMP	Pest Management Plan
PNSFR	National Rural Land Security Program
QA	Quality Assurance

QC	Quality Control
REDD+	Reducing Emissions from Deforestation and forest Degradation
RL	Reference Level
SEP REDD+	Permanent Executive Secretariat for Reducing Emissions from Deforestation and Forest Degradation
SESA	Strategic Environmental and Social Assessment
SESMP	Simplified Environmental and Social Management Plan
SIS	Safeguards Information System
SLM	Spatial Land Monitoring
SN-REDD+	Strategy National REDD+
SODEFOR	Forest Development Corporation
SOP	Standard Operational Procedure
STI	Sustainable Trade Initiative
TMF	Tropical Moist Forest
TNP	Tai National Park
TOR	Terms of Reference
UNFCCC	United Nations Framework Convention on Climate Change
URPCI	Union of Rural Radios of Côte d'Ivoire
WB	World Bank

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

Status of actions and interventions undertaken under the ERP

Slash and burn agriculture are the main drivers of deforestation in Côte d'Ivoire in general and in the ERP in particular. To address these drivers of deforestation and forest degradation, the ERP is being implemented using a landscape approach to address all drivers of deforestation and forest degradation in a coordinated and effective manner. This landscape approach builds on the linkages between agricultural development, natural resource management and governance and aims to maximize economic, environmental and social benefits.
The ERP as designed will capitalize on emission reductions from (i) reducing deforestation, (ii) reducing forest degradation, (iii) preserving residual forests, and (iv) increasing forest carbon stocks. To this end, several projects and initiatives underway in the program area are aligned to contribute to the achievement of the program's GHG emission reduction objectives. These include:

Table 1: Ongoing projects and initiatives in the ER-Program area

Project	Activity	Summary of progress achieved
FIP (1st phase) 2018-2023	The objective is to conserve and increase the forest stock and to improve the access of communities in the targeted areas (central and southwestern part of Côte d'Ivoire) to sources of income induced by sustainable forest management. The objectives are: i. Restoration of forest cover in classified forests and riparian zones; ii. Sustainable management of the Taï National Park (TNP);	- 14,289.34 hectares of agroforestry established in classified forests. The database in shapefile format is available here ; - 5000 hectares of agroforestry established outside of classified forests The report of this activity is available here ; - 2 participatory management plans for classified forests (Haute dodo and Rapide grah)
Payment for Environmental Services (PES) Nawa 2017-2020	PES pilot project as part of the Cocoa Life program operating in the Nawa region. The objectives are: i. eliminate deforestation in the supply chain; And ii. contribute to the objective of restoring Ivorian forest cover through a PES-type incentive instrument	- Feasibility study of PES and practical guide to PES ; - Establishment of a national working group on PES, a regional steering committee and installation of 5 groups of foresters in 2 regions ; - Training of 200 women on forest tree production techniques with production of 200,000 trees, 18 cooperative relay trainers and 903 cocoa producers trained in agroforestry techniques and 71 young people from communities trained in forestry techniques ; - Installation of nursery groups with supplies of seeds, materials and equipment in 5 localities in the region

		- 2071 hectares of agroforestry carried out and signing of 1020 Agroforestry PES contracts ; - Reforestation of 26 hectares; - Conservation of 34 hectares of individual natural forests. The final activity report is available here.
ICF (1st phase) 2018–2021	The overall objective of the Initiative is to preserve and rehabilitate the forests of Côte d'Ivoire in conjunction with the sustainable production of cocoa and the improvement of sources of income for producers.	- More than 12,945,000 trees distributed for agroforestry and reforestation ; - More than 22,000 hectares of forests restored in rural areas ; - 193,395 hectares of cocoa agroforestry under development ; - More than 12,700 farmers benefiting from payments for environmental services ; - More than 387,200 farmers trained in good agricultural practices: more cocoa on less land ; - 249,807 farmers trained in smart practices in the face of climate change ; - More than 114,200 farmers benefiting from financial products and services ; - Improved traceability with mapping of more than 465,400 farms ; - Improved livelihoods of farmers through income-generating activities (production and sale of other agricultural products than cocoa, livestock or non-agricultural activities). The reports of activities carried out in ICF are available here
ISLA (Initiative for Sustainable Land Use) IDH	Develop a balance between forest, agriculture and populations; in doing so, ISLA will support the implementation of public and private sector commitments towards net zero deforestation and green growth on the ground in the TNP area.	- Development of a Regional Scheme for Planning and Sustainable Development of the Cavally Territory (SRADT) with a green growth strategy; - Promotion of agroforestry practice - Restoration of forest cover ; - Diversification of producers' activities ; - Development of financial incentive measures and the creation of a public-private investment mechanism for sustainable and ecological land development. The report is available here
Regional Indicative Program - 11th EDF Union 2019-2025	PIR- 11th EDF West Africa - Priority Area 3: Resilience, Food and Nutrition Security and natural resources - Support for Tai National Park	- Protection and conservation of Taï National Park (TNP) ; - Development of the territory around TNP ; - Support for local development around TNP ;

		- Fight against land degradation ; - Improvement of the productivity of food and energy wood sectors (agroforestry), to sustainably generate production surpluses and jobs, particularly for women in both rural and peri-urban areas ; - Integration of trees into production systems for their contribution to soil management ; - Respect for sustainable land management techniques, including measures related to sustainable natural resource management. National indicative program report can be found below for : - 2014-2020 - And 2021-2027
Dedicated Grant Mechanism (DGM) for Cote d'Ivoire	This project, which supports the Forest Investment Project (FIP), aims to strengthen the capacity of targeted local communities (living around forests) to participate in the sustainable management of forests and lands, as well as in the REDD+ processes at the local, national, and global levels; and maintain and increase forest cover in targeted areas. It is structured around three components: i. capacity building of local communities, ii. development and implementation of an incentive system to reduce pressure on forest resources iii. project management, monitoring and communication (information and awareness).	- Capacity building of 157 promoters (86 women and 61 men) in their fields of activity through training in microproject management in agropastoralism ; - Development and implementation of a performance-based system to reduce pressure on forest resources ; - Establishment of grievance redress mechanism in different localities ; - Strengthening the capacities of local communities in agroforestry and forest restoration and REDD+ activities - Continuous awareness-raising on the prohibition of pesticides and any other chemical products in the implementation of income-generating agricultural activities. The project report can be found here.
Spatial Forest Monitoring and Deforestation Early Warning System	The Geoportal for Land Monitoring System (LMS) is a web portal that aims to visualize and provide access to updated national data on the evolution of natural resources. The early warning system for deforestation should allow for the rapid detection of forest infiltrations and trigger follow-up	Consultations with various national stakeholders enabled finalizing the specifications for the Land Monitoring and Early Warning System for deforestation. It was adopted by the government in March 2023. The next step is to recruit a service provider for the development of the platform planned in 2024.

	and control operations on the ground to remedy them.	

Strategic updates established to mitigate/minimize displacement

Efforts are made to minimize emissions displacement outside the program area. This is mainly due to the fact that the proposed measures are mostly incentives rather than coercive measures that could lead to emissions displacement outside the program area.
In addition, the MRV system uses satellite monitoring procedures and tools to assess and track annual deforestation at the national level to ensure that there is no additional deforestation/forest degradation outside the program area due to program implementation. Work is underway to make available on its geoportal the results obtained by the MRV system, which is an integral part of the national forest monitoring and deforestation early warning system that is planned to be operational by 2024.
The causes of deforestation remain unchanged, all the strategies described in the ERPD (Table 2) are being implemented and the risk of displacement is still assessed and classified as low for (i) cocoa farming expansion and (ii) artisanal gold panning and medium for (i) illegal logging and (ii) demographic pressure due to population migrations to the program area.

Table 2: Strategies to combat deforestation and forest degradation

Drivers of deforestation or degradation	Displacement risk	Strategy / Action
Expansion of agriculture	Low	- Rationalize land use with land use planning ; - Integration of agroforestry in the practices of cocoa producers established in classified forests and to apply improved management of classified forests with the establishment of participatory management, and the contractualisation of agricultural and forestry activities ; - Intensify cocoa production in agroforestry to reduce the need for land in rural areas. These actions can be consulted in detail in the *Zero Deforestation Agriculture* section of the REDD+ National Strategy downloadable at this link.
Illegal logging of timber and fuelwood	Medium	Production of fuelwood, timber, and the use of improved stoves, promotion of butane gas and the use of agricultural residues and agro-industrial by-products.
Artisanal gold panning	Low	- Strengthen the surveillance capacity of OIPR to prevent any intrusions and monitor these borderline activities ; - Identify artisanal gold miners, restructure the sector with the implementation of the mining code. The gold panning rationalization program can be viewed at the following link.
Demographic Pressures (migration into the ERP zone)	Medium	- Contractualization of occupants of individual or community forest concessions to carry out agroforestry activities, participatory and improved management of classified forests, participatory development plan under preparation (Haute dodo and Rapide grah forest management plans) - Clarification and securing of land tenure and conflict resolution through the National Program for Securing Rural Land (PNSFR) which was launched in July 2018 and is led by AFOR through the PNSFR,

		which is implemented through several projects including PAFR which can be view here.

Effectiveness of organizational arrangements and involvement of partner organizations

Institutional arrangements for program implementation are in place and are effective. The entities involved and partners in program implementation are the most relevant in terms of their responsibilities, activities carried out, and their link with program objectives.

The political and cross-sectoral commitment of the various ministries for REDD+ is materialized by the creation, by Decree, of a **National REDD+ Commission,** an intersectoral organization for analysis, counselling and guidance for the implementation of the REDD+ mechanism in Côte d'Ivoire. It is composed of:

- a **National REDD+ Committee** (CN-REDD+) in charge of steering the REDD+ mechanism;
- a **REDD+ Interministerial Technical Committee** (CTI REDD+) in charge of intersectoral coordination, proposing to CN-REDD+ the main guidelines for reducing emissions from deforestation and forest degradation, and planning the implementation of CN-REDD+ decisions;

  and a **REDD+ Permanent Executive Secretariat** (SEP-REDD+) which is responsible for implementing the REDD+ process, mechanisms and tools at the national level. It is responsible for coordinating the actions and investments of all players to achieve the objectives in terms of reducing emissions and compliance with environmental and social safeguard directives. It also ensures (i) the monitoring of reduced emissions, (ii) the monitoring of the implementation and compliance with environmental and social safeguard standards, the monitoring of complaints and appeals and the application of conflict resolution decisions and (iii) reporting to the World Bank carbon fund.

The Ministry of Economy and Finance (MEF), signatory of the ERPA contracts, is the entity responsible for the implementation and success of the program. It is responsible for managing the register of carbon transactions and transfers of emission reduction titles resulting from the implementation of the program. It transferred responsibility of distributing monetary benefits to program beneficiaries, as per a subsidiary agreement, to the **Foundation for Parks and Reserves of Côte d'Ivoire** (FPRCI).

The Ministry of the Environment is the administrative authority of SEP-REDD+, OIPR and ANDE.

- **Ivorian Office of Parks and Reserves** (OIPR): Responsible for the management of National Parks and nature reserves including the Taï National Park, Mount Peko National Park and the N'zo natural reserve complex, making it the largest West African primary tropical forest under protection. OIPR ensures the management of ER targeted national parks through enhanced patrolling, natural regeneration of degraded areas and awareness raising at the local level to ensure avoided deforestation.
- **National Environment Agency** [1](ANDE): The ANDE's fundamental mission is to ensure that environmental concerns are taken into account in policies, plans, programs (PPP), and development projects initiated in Côte d'Ivoire. As such, it aims to effectively encourage all project holders to comply with national environmental regulatory requirements and to integrate their activities into a sustainable development approach. To do so, it has three (03) tools based on current regulatory texts that constitute the core of its major activities: (i) Strategic Environmental Assessment (SEA), (ii) Environmental and Social Impact Assessment (ESIA), and (iii) Environmental Audit (EA). All project activities included in the PRE receive support from ANDE in this regard. The Forest Investment Project (Phase 1) is among the projects receiving such support.

The Ministry of Water and Forest (MINEF): Responsible for the preparation and implementation of Government policy on the management of forest, wildlife and water resources. It also coordinates the cocoa and forests initiative and it is the supervisory ministry for:

[1] www.ande-ci.com

- The **Forest Development Company** (SODEFOR): whose mission is to participate in the development and implementation of Government policy in terms of enriching the national forest heritage, developing forest production, enhancing the value of products and safeguarding forest areas. It is responsible for the management of 234 classified forests spread throughout the national territory, including 24 in the programme area.

The **Ministry of State, Ministry of Agriculture and Rural Development** (MEMINADER): Responsible for the implementation of agricultural policy at the national level. It is also the administrative guardian of:

  - **National Rural Development Support Agency** (ANADER): its mission is to "contribute to the improvement of living conditions in the rural world through the professionalization of farmers and professional agricultural organizations by designing and implementing appropriate tools and approaches, programs adapted to ensure sustainable and controlled development". As such, it provides support to farmers in the program area with regard to the implementation of sustainable practices.
  - **Coffee-Cocoa Board**: is responsible for managing all activities related to the Coffee-Cocoa sector in Côte d'Ivoire. It has several missions, including regulating, stabilizing and developing the sector. Its role is to bring technological innovations and scientific research closer to producers and to support rural producers in adopting best practices related to smart agriculture, intensification and agroforestry;

- Private operators in the agricultural sector and the timber sector
- NGOs
- Bilateral agencies.

Their role is to develop and implement activities aimed at reducing greenhouse gas emissions in the program area.

1.2 Update on major drivers and lessons learned

The drivers of deforestation and forest degradation initially described in the program area through Nitidae and BNETD (2016)[2] have not changed since the ERPD was written.

These are mainly agriculture, with cocoa farming in the lead, uncontrolled logging, bush fires (accidental or intentional, often linked to agriculture or hunting) and mining, particularly illegal artisanal gold panning. This information has been confirmed by the data assessment work on activities, the detailed results of which can be found in section 3.

To address these factors of deforestation and forest degradation, various measures are taken while minimising the risk of displacement of populations from the programme area. These measures include agroforestry and agricultural intensification with sustainable agricultural practices, land-use planning and development, rehabilitation of gold panning sites plus income-generating activities, participatory management of classified forests between local communities and managers, and the issuing of land certificates. These measures are detailed in section 1.1.

All these measures are implemented through various projects, including the FIP, the Nawa PES, the activities of the private cocoa sector, and the National Rural Land Tenure Security Program (PNSFR), described in detail in section 1.1 by the partner entities also presented in section 1.1.

Several lessons have been learned in mitigating displacement risks. Thus, the strategies associated with these risks show that they are low for agricultural expansion and artisanal gold mining, and medium for illegal exploitation of energy wood and timber, and the displacement of populations outside the program area. The activities implemented to mitigate displacement risks are adapted to local economic and social conditions, and are mainly based on incentives, rationalization and sustainable management of natural resources exploitation and the valorization of non-carbon benefits. With regard to demographic pressure exerted on the program area, all activities currently being carried out at the national or regional level have helped limit the effect of demographic pressures. These are:

[2] Nitidae and BNETD (2016):Qualitative analysis of drivers of deforestation and forest degradation in Côte d'Ivoire http://reddplus.ci/download/analyse-qualitative-des-facteurs-de-deforestation-et-de-degradation-des-forets-en-cote-divoire-2/

- Planning of land use and development, through support for the integration of development and management plans for protected areas (SRADT) Community plantations - food and energy wood associations in classified forests ;
- Strengthening the capacities of local communities in forest management through the Forest Investment Project.

Finally, the traceability program developed as part of the Cocoa and Forests Initiative and the “zero-deforestation” policy for monitoring the cocoa supply chain coupled with the National Forest Monitoring System (NFMS) make it possible to track and detect deforestation and degradation through satellite image interpretation and on the ground. Movement surveillance is monitored both inside and outside the program boundaries.

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

2.1 Forest Monitoring System

The monitoring system, whose role is to assess the country's performance in reducing emissions from deforestation and forest degradation, is implemented with several national actors according to their fields of competence.

In Côte d'Ivoire, SEP-REDD+ has the lead on National Forest Monitoring System (NFMS) activities. As such, it coordinates the work of stakeholder organisations, both at the national level and in the ERP zone, for (i) estimating data on land use change activities, (ii) estimating biomass and emission factors for the different relevant vegetation strata, (iii) estimating GHG emissions/removals due to REDD+ activities, and (iv) notifying GHGI to partners for verification.

The organisations in charge of producing activity data (AD) are:

- BNETD/CIGN is the national reference centre for map production (topographic maps and thematic maps). It produces mapping data and develops geographic information systems necessary for the study, implementation and operation of land use planning. It coordinates and controls mapping and remote sensing work on behalf of the State of Côte d'Ivoire. In general, these are "wall-to-wall" maps that are produced from satellite image processing coupled with data collection campaigns in the field;
- CNTIG which is responsible for defining policy, organising and coordinating programmes in the field of geoinformation and applied remote sensing;
- SODEFOR is the entity responsible for providing data (geographical, socio-economic, and other statistics) related to the sustainable management of classified forests;
- OIPR is responsible for providing data (geographical, socio-economic, and other statistics) related to the management of parks and reserves;
- SEP-REDD+ is responsible for the compilation, quality control and archiving of data collected by national entities and the estimation of uncertainties associated with the surface areas of the strata
- Universities and research centres (CURAT, IGT, CNF, CSRS and INPHB) contribute to the development of methodologies and quality control of data collected by other organisations producing data on activities. In addition, the data ;

The organisations in charge of producing data on biomass and emission factors are:

- The Ministry in charge of forests (MINEF) which is the national organisation in charge of carrying out forest and wildlife inventories. As such, a national inventory of forest and wildlife resources was carried out between 2019 and 2021, in partnership with SODEFOR, OIPR and ANADER;
- SEP-REDD+, which in 2016, in partnership with SODEFOR, conducted a forest inventory to estimate the biomass of forests;
- SODEFOR, which collects dendrometric data as part of the development inventories of the classified forests under its management;
- Universities and research centres which, as part of their research work, collect dendrometric data in various ecosystems, both forest and agricultural, which are used to estimate emission factors. They also participate in the quality control of the data collected by the above-mentioned entities.

The estimation of GHG emissions/removals and emission reductions achieved from the implementation of projects and other policies on land use/land cover changes is the responsibility of SEP-REDD+.

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

The data used for the GHG inventory come, as indicated in the previous paragraph, from different sources. The choice of data to be used depends on a number of factors including: (i) the spatial and temporal coverage of the data, (ii) the suitability of the methodology used for its production and standard operating procedures.
National data are preferred when they meet the above conditions. Otherwise, or in the absence of relevant national data, data are sought from relevant international databases.
For the same category of data, the data are compiled, cleaned, consolidated and archived in databases designed for this purpose and available on the SEP-REDD+ servers. This makes it possible to make them accessible later for processing but also and above all for any verifications that may be necessary.
Thus, the mapping data used for the calculation of the country's emissions or the ERP were produced by BNETD/CIGN following a methodology validated at the national level by the various stakeholders such as universities, research centres and competent national organisations. This methodology also includes the process of validation of the data produced, which meets national and international standards.
Missing biomass data are selected based on different sources of information such as research results conducted in the country or in the sub-region and published, e.g. the values used for agroforestry and cocoa biomass.

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

Initially, for the production of activity data, data collection was carried out by BNETD/CIGN with the participation of other organisations such as CNTIG, SODEFOR, OIPR and universities and research centres (CURAT, IGT).
This data collection was carried out at two levels : the collection of satellite images on relevant websites[3] and the collection of field data to serve as training data for classification algorithms. The data produced underwent validation at national level before publication. This validation consisted of photo-interpretation, using tools such as Collect Earth or free open-source mapping software of sample units produced according to a stratified random design.

However, it should be noted that the methodology for estimating the AD has been improved in terms of the type of sampling and size. This change is in response to technological developments in data, tools and new technical considerations (Pagliarella, 2017[4]; McRoberts et al., 2018[5]).

Indeed, accurate and precise estimates of land cover/land use change area are essential to compare and measure the effect of policies and activities to mitigate, adapt or prevent climate change impact. However, individual maps contain errors which, when combined to make land cover area estimates, increase bias and prevent the characterisation of land use change to the standards required by the international community.

The methodological approach developed in 2018 for the ERPD described area estimates through a combination of data based on visual interpretation of sampling units and the use of maps. In practice, it consisted of using classified and combined maps to design a reference sample according to the practices described by Olofsson (2013[6], 2014[7]). This approach used by SEP REDD+ in 2018 for the FREL development of the ERP was updated in October 2022 with support from the World Bank, FAO and the Institut Géographique National-France International (IGN- FI), to measure reduced emissions in a robust and more accurate manner.

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[3] CNES website for Spot Word Heritage : https://regards.cnes.fr/user/swh/modules/60
Earth explorer : https://regards.cnes.fr/user/swh/modules/60
European Space Agency website : https://sentinel.esa.int/web/sentinel/access-to-sentinel-data-via-the-copernicus-data-space-ecosystem
[4] Pagliarella, et al. 2018. Spatially-balanced sampling versus unbalanced stratified sampling for assessing forest change: evidences in favor of spatial balance. https://sci-hub.wf/10.1007/s10651-017-0378-y
[5] McRoberts, et al. 2018. The effects of imperfect reference data on remote sensing-assisted estimators of land cover class proportions.https://sci-hub.wf/10.1016/j.isprsjprs.2018.06.002
[6] Olofsson, et al. 2013. Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation. https://sci-hub.wf/10.1016/j.rse.2012.10.031
[7] Olofsson, et al. 2014. Good practices for estimating area and assessing accuracy of land change. https://sci-hub.wf/10.1016/j.rse.2014.02.015

In the new approach, the interpreted sampling units for the estimation of land use change areas are distributed according to a systematic sampling grid spaced at 1 km, which leads to a very dense sampling design (i.e. 46415 points () over the ERP area, 4000 of which are intended for visual and fixed interpretation, i.e. the same sampling will be used for the collection of past and future data. In order to harmonise the interpretations between the different operators and to reduce as much as possible the interpretation errors that could induce noise in the results, the process of sampling unit visual interpretation has been standardised by developing interpretation keys (link available here).

To carry out the data collection, a joint mission of the World Bank, FAO, IGN-FI, and SEP-REDD+ was organised in Paris, France from 12 to 16 December 2022. The objective was the production of activity data intended for preparing the project's first ER monitoring report.
The information on emission/absorption factors comes from the 2016 national forest inventory conducted by MINEDD through SEP-REDD+ and SODEFOR.

- **Systems and processes that ensure the accuracy of data and information**

Various processes and systems are in place to ensure the accuracy of the data and information produced by the MRV system. These are:

- The implementation of QA/QC processes in all data production processes ;
- The development of standard operating procedures (SOPs) for the collection, processing, archiving and management of data. They are described in detail in the below paragraphs ;
- Capacity building of national organisations in the implementation of standard procedures to produce data and information in their field.

This offers the advantage of having more or less consistent data between them,which even when they are produced for smaller scales can be aggregated between them.
The Côte d'Ivoire MRV team received technical support from experts from the World Bank, FAO and the Institut Géographique National France International (IGN-FI). The experience gained from this collaboration will allow the reproducibility of data for future reporting periods in complete autonomy.

- **Design and maintenance of the Forest Monitoring System**

Côte d'Ivoire has received financial support from the C2D and the World Bank for the establishment of its Spatial Land Monitoring system. A geoportal has been developed within this framework and improvements are in progress in order to allow the consultation of data and emission factors by stakeholders and the general public. This portal is managed by the SEP-REDD+ and maintained by the CNTIG.
It should be noted that this system is in the reorganization phase and will be finalized in May 2023 for the integration of new functionalities meeting user expectations in terms of MRV, information on social and environmental safeguards as well as the register of projects and REDD+ initiatives.

- **Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures (SOPs) and QA/QC procedures**

The daily management of classified forests is carried out by SODEFOR. While that of the rural domain is carried out by the MINEF. It should also be noted that the parks and reserves are monitored and administered by the OIPR. All these entities are responsible for carrying out forest monitoring actions in their respective areas of intervention. For Quality Assurance and Quality Control, Standard Operating Procedures (SOPs) have been produced on the Sampling, Response and Analysis System.
They constitute a guide allowing the respect of the quality in the estimate of the AD but also in the replication of the processes. These different SOPs make it possible to successively describe the following steps:

- SOP1: Design of the sampling plan
- SOP2: Response system
- SOP3: Baseline data collection
- SOP4: Analysis system

A field data collection manual has been designed for compliance with forest inventory data collection procedures in addition to field verification. This manual is available here.

- **Role of local communities**

Given the role of local communities is explicitly mentioned in the Cancun Agreements of the UNFCCC, Côte d'Ivoire has identified local communities as an important link in collecting and sharing information related to forest monitoring. In this context, a pilot project for community forest monitoring was carried out in 2018 in Mé region, which made it possible (i) to define the potential role of communities in the forest monitoring system and (ii) to strengthen their capacities to enable them to play this role effectively. Thus, local communities organized into NGOs have been trained in the use of GPS, methods for collecting and transferring data related to land use, methods for collecting data for forest inventory, etc.

The experience gained in previous projects has been capitalized upon for the implementation of the program. Thus, local communities play the following role:

- Traditional authorities and NGOs participate in information, awareness-raising and stakeholder mobilization activities for the implementation of project activities and ensuring their continuity. ;
- Local communities organized into NGOs, associations and others are responsible for contributing to the identification, mapping and monitoring of the achievements of direct project beneficiaries.

- **Use of basic technical procedures, their uniformity in the country and their consistency with the National Forest Monitoring System**

All procedures and methodologies to produce AD and Emission Factors (EFs) are defined and validated at the national level by all actors in the NFMS. The methodologies designed by these structures (BNETD, CURAT, IGT, CNTIG, SODEFOR, OIPR MINEF),are the same and respond to the local and international context and the roles and responsibilities of the different national organisations remain identical.

The map captions have been harmonised and are used by all the national organisations in their various productions (land use maps and NFWI).

The collection procedures on EFs are the same used at national and sub-national level. It is worth recalling that the procedure for producing ADs recently updated with the support of the World Bank, FAO and IGN-FI, is the one that will be used for the determination of the subsequent AD both at the sub-national and national levels in the framework of the development of FRELs.

2.2 Measurement, monitoring and reporting approach

2.2.1 Line Diagram

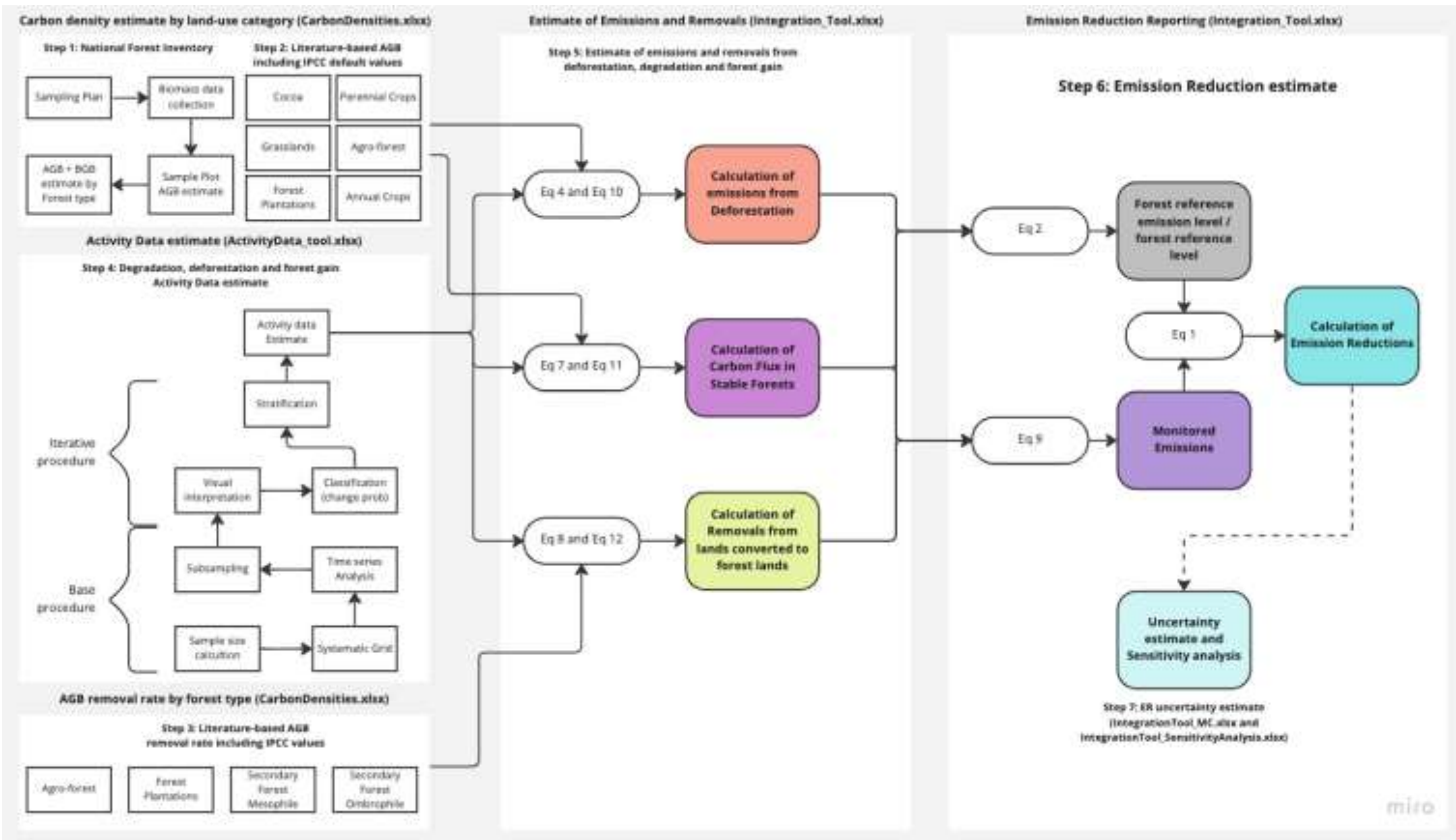

Figure 1: Organizational structure and GHG estimation method

2.2.2 Calculation

Emission reduction calculation ($ER_{ERP,t}$):
To determine GHG emission reductions, the same IPCC methods and equations described in Section 8.3 were used over the monitoring period.

$$ER_{ERP,t} = RL_t - GHG_t \qquad \textit{Equation 1}$$

Where:

ER_{ERP}	=	Emission Reductions under the ER Program in the Reporting Period; tCO_2.
RL_{RP}	=	Net emissions of the Reference Level over the Reference Period; tCO_2e. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.
GHG_t	=	Monitored gross emissions from deforestation during the Reporting Period; tCO_2e;
T	=	Number of years during the reporting period; dimensionless.

Reference Level (RL_{RP})
The RL estimation may be found in Annex 4, yet a description of the equations is provided below.
Net emissions of the RL from deforestation over the Reference Period (RL_{RP}) are estimated as the sum of annual change in total biomass carbon stocks (deforestation and degradation), and annual removals (ΔC_{B_t}) during the reference period.

$$RL_{RP} = \frac{\sum_t^{RP} \Delta C_{LU_{RP,i,t}}}{RP} \qquad \textit{Equation 2}$$

Where:

$\Delta C_{LU_{RP,i,t}}$	=	Balance of emissions during the Reference Period in the Accounting Area of the ER Program that corresponds to the sum of annual change in carbon stocks and removals for each of i REDD+ activities at year t; tCO_2*year^{-1}.
RP	=	Reference period; years.

Technical corrections: The reference level for the ERP was initially determined for 16 years (January 1, 2000 to December 31, 2015) in line with the reference level submitted to the UNFCCC in 2017. However, according to criteria 11.2 and 16 of the Methodological Framework, the reference period should not exceed 15 years. To correct this issue, a pro-rata estimate of a 15-year Forest Reference Emission Level / Forest Reference Level was calculated. Considering that the reference period was estimated based on two monitoring events (2000-2010 and 2010-2015), the emission of the 2000-2010 period was pro-rated to an adjusted period 2001-2010. Finally, the new Reference Level was calculated by adding adjusted emissions of 2001-2010 with emissions of 2010-2015 to obtain the reference level emission adjusted to 15-year reference period.

Annual change in total biomass carbon stocks forest land converted to another land-use category ($\Delta C_{B_{defo,t}}$)

Emissions from deforestation were estimated based on the Deforestation Sheet of Activity data tool following the 2006 IPCC Guidelines, the annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta C_{B_{defo,t}}$) would be estimated through the following equation:

$$\Delta C_{B_{defo,t}} = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

Equation 3 (Equation 2.15, 2006 IPCC GL)

Where:

$\Delta C_{B_{defo,t}}$	Annual change in carbon stocks in biomass on land converted to other land-use category, in tones C yr^{-1};
ΔC_G	Annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tones C yr^{-1};
$\Delta C_{CONVERSION}$	Initial change in carbon stocks in biomass on land converted to other land-use category, in tones C yr^{-1}; and
ΔC_L	Annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tones C yr^{-1}.

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document[8] for applying IPCC Guidelines and guidance in the context of REDD+, the above equation will be simplified and it will be assumed that: a) the annual change in carbon stocks in biomass ($\Delta \boldsymbol{C_B}$) is equal to the initial change in carbon stocks ($\Delta \boldsymbol{C_{CONVERSION}}$); b) it is assumed that the biomass stocks immediately after conversion is the biomass stocks of the resulting land-use. Therefore, the annual change in carbon stocks would be estimated as follows:

$$\Delta \boldsymbol{C_B} = \Delta \boldsymbol{C_{CONVERSION}}$$

$$\Delta C_{B_t} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) \text{ x CF x} \frac{44}{12} \times A(j,i)_{RP}$$

Equation 4 (Equation 2.16, 2006 IPCC GL)

Where:

[8]Page 44, GFOI (2013) Integrating remote-sensing and ground-based observations to estimate emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.

$A(j, i)_{RP}$ Area converted/transited from forest type j to non-forest type *i* during the Reference Period, in hectares per year. In this case, twenty-four forest land conversions are possible:

1 Agro-forest to Cocoa
2 Agro-forest to Grassland
3 Agro-forest to Human settlement
4 Agro-forest to Other crops
5 Agro-forest to Other lands
6 Agro-forest to Perennial crops
7 Dense Forest to Cocoa
8 Dense Forest to Grassland
9 Dense Forest to Human settlement
10 Dense Forest to Other crops
11 Dense Forest to Other lands
12 Dense Forest to Perennial crops
13 Forest plantations / reforestation to Cocoa
14 Forest plantations / reforestation to Grassland
15 Forest plantations / reforestation to Human settlement
16 Forest plantations / reforestation to Other crops
17 Forest plantations / reforestation to Other lands
18 Forest plantations / reforestation to Perennial crops
19 Secondary Forest to Cocoa
20 Secondary Forest to Grassland
21 Secondary Forest to Human settlement
22 Secondary Forest to Other crops
23 Secondary Forest to Other lands
24 Secondary Forest to Perennial crops

Technical corrections. Initially, in the ERPD, activity data was determined based on the combination of several maps on which a random sampling system is applied to carry out visual interpretations through operators, as recommended by Olofsson et al. (2013 and 2014). Although this approach reduces the errors of omission of change, they remain significant. A hybrid approach for estimating areas has been adopted to correct these errors and obtain relevant and precise results.

$B_{Before,j}$ Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground ($AGB_{Before,j}$) and belowground biomass ($BGB_{Before,j}$) and it is defined for each forest type.

$B_{After,i}$ Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest IPCC Land Use categories.

Technical corrections. **Forest carbon densities**: Dense Forest and secondary forest biomass values have been updated considering the recommendations of Carbon Fund participants in 2019 relating to the plot stratification approach. Indeed, the initial approach developed in the ERPD indicated a classification of the sampling units of the forest inventory based on the rate of cover estimated from the visual interpretation of satellite images, deemed irrelevant. Data updating is based on direct field observations that inventory teams provide during surveys. Field sheets[9] and database[10] describing the land cover category of the sampling units are available. Biomass values related to agroforests and forest plantations under the ER Program were obtained through the literature. These are the results from work carried out by Asigbaase et al., (2021)[11] in Ghana. Indeed, before the submission of the ERPD in January 2019, no legal texts were ruling on the agroforest category as a forest class. Since the clarification provided by the forest code LAW N ° 2019-675 OF JULY 23, 2019, available here, this correction has been considered by integrating emission factors from the agroforest category. **Non-Forest carbon densities**: Initially, it was assumed that Cocoa biomass is carbon density for non-forest land use. Other non-forest land use was included in the carbon accounting due to the re-calculation of activity data. Therefore, the following carbon densities were included in the calculation of emissions from deforestation: perennial crops, annual crops, and grassland. The biomass values for these land uses were obtained through the literature.

For the aboveground biomass of the annual crop category, the value from IPCC GL 2006, TABLE 5.9, Volume 4, Chapter 5 was used as country specific data is not available.

	AGB		
Other crop (annual)	**tdm/ha**	90% Confidence Interval [tdm/ha]	90% Confidence Interval [%]
	5.53	4.15	75%

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.

44/12 Conversion of C to CO_2

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{deg,t}}$)

Following the 2006 IPCC Guidelines the annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{DEG}}$) could be estimated through the Gain-Loss Method or the Stock-Difference Method as described in Chapter 2.3.1.1 of Volume 4 of the 2006 IPCC Guidelines.

$$\Delta C_B = \Delta C_G - \Delta C_L$$ **Equation 5** (Equation 2.7, 2006 IPCC GL)

$$\Delta C_B = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$ **Equation 6** (Equation 2.8 (a), 2006 IPCC GL)

ΔC_B Annual change in carbon stocks in biomass for each land sub-category, in tones C yr^{-1}

ΔC_G annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, tones C yr-

ΔC_L annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, tones C yr-1

C_{t_2} total carbon in biomass for each land sub-category at time t_2, tonnes C

[9] NFI Field sheets: https://drive.google.com/drive/folders/1FZjLxTm6qc5RakJ0x2GoOuQNqVbaTNLg?usp=share_link

[10] NFI land cover category database - http://reddplus.ci/download/forest-type-biomass/

[11] Asigbaase, Michael; Dawoe, Evans; Lomax, Barry H.; Sjogersten, Sofie (2021). Biomass and carbon stocks of organic and conventional cocoa agroforests, Ghana. Agriculture, Ecosystems & Environment, 306(), 107192–. doi:10.1016/j.agee.2020.107192 https://sci-

C_{t_1} total carbon in biomass for each land sub-category at time t_1, tonnes C

Following the recommendations set in chapter 2.2.2 of the GFOI Methods Guidance Document[12] for applying IPCC Guidelines and guidance in the context of REDD+, the above equation will be simplified, and it will be assumed that: a) the annual change in carbon stocks in biomass (ΔC_B) due to degradation is equal to the annual decrease in carbon stocks (b) the decrease in carbon stocks occurs the year of conversion. The long-term decrease in carbon stocks indicated in equation (1) of the GFOI MGD is assumed here to be zero. Therefore, considering the GFOI MGD the IPCC equation for forest degradation could be expressed as an Emission Factor time activity data as follows:

$$\Delta C_{B_{DEG}} = \sum_{j} \{EF_j \times A(a,b)_{RP}\}$$ **Equation 7**

Where:

EF_j Emission factor for degradation of forest type a to forest type b, tones CO_2 ha^{-1}.

$A(a,b)_{RP}$ Area of forest type a converted to forest type b (transition denoted by a,b) during the Reference Period, ha yr^{-1}.

Technical corrections. Initially, the forest degradation emissions estimate corresponded to the area of forest land remaining in the Forest Land category with a decrease in cover and biomass in the Ombrophilics and mesophilic areas. It had been considered as forest degradation in those forest areas with a forest cover rate of more than 70% in 2000, which decreased to a forest cover rate between 30-70% in 2015. Now, this calculation corresponds to the areas of forested lands converted into other forest types. All transitions between secondary and dense forests, agroforests, and forest plantations are considered

The below equations are the result of the technical corrections applied to the Program:

Annual change in carbon stocks in biomass on non-forestland converted in forestland ($\Delta C_{B_{reg}}$)

Land converted to forest land CO2 removals has been estimated following the recommendations set in the Guidance Note for accounting of legacy emissions/removals of the FCPF (version 1). Since the FCPF Methodological Framework requires IPCC Tier 2 or higher method, the net annual CO2 removals are calculated using equations 2.15 and 2.16 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. These equations were simplified by assuming that the conversion from non-forest to forest occurs during a period from average carbon stocks in non-forest to average carbon stocks in forests. A conservative default period of 20 years is assumed for the forest to grow from the carbon stock levels of non-forest to the level of biomass in the average forest. The removal estimate considers changes in carbon stocks in aboveground biomass. Using the outcome of equation 2.15 and 2.16, it was determined the changes in the total carbon stocks in biomass (removals) during the reference period as the sum of the total carbon stocks in biomass of all land units. From the point of view of notations, the emission factors in equation EQ7 above would be replaced by $\mathbf{RF}_{SREG}$ in enhancement of carbon stocks in new forests.

$$\Delta C_{B_{reg}} = \sum_{LU=1}^{n} \{RF_{reg} \times A(i,j)_{RP}\}$$ **Equation 8**

Where:

RF_{reg} enhancement of carbon stocks in new forests [tCO2*ha*$year^{-1}$].

[12]Page 48, GFOI (2013) Integrating remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.

$\boldsymbol{A(j,i)_{RP}}$	Area of non-forestland *i* converted to forestland *j* (transition denoted by *i,j*) in the Reference Period, ha yr^{-1}.
LU	Land unit.

Technical corrections. Carbon removals estimate include all secondary forest cohorts regenerated after 2000. The Secondary Forest regenerated before the reference period is assumed as Degraded Forests. Land converted to forest land CO_2 removals have been estimated following the recommendations set in the Guidance Note for accounting of legacy emissions/removals of the FCPF (version 1). A conservative default period of 20 years is assumed for the forest to grow from the carbon stock levels of non-forest to the level of biomass in the average forest. The removal estimate considers changes in carbon stocks in aboveground biomass. The changes in the total carbon stocks in biomass (removals) during the reference period were determined as the sum of the total carbon stocks in biomass of all land units. **Removal factors**: in the ER-PD the removals estimate is based on native forest regeneration only. Forest plantation and Agro-forest removals were included. For forest plantations and agroforestry systems IPCC (2006) values of tables 5.2 and 4.10 were used.

AGB			
$\boldsymbol{RF_{reg}}$ < 20 years	**tdm/ha**	90% Confidence Interval [tdm/ha]	90% Confidence Interval [%]
	195.5 tdm/ha	175.95	90%

BGB annual growth was excluded.

Monitored emissions ($\mathbf{GHG_t}$)

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 (ΔC_{B_t}).

$$GHG_t = \frac{\sum_t^T \Delta C_{LU_{MP,i,t}}}{T}$$ **Equation 9**

Where:

$\Delta C_{LU_{MP,i,t}}$	=	Balance of emissions during the Monitoring Period in the Accounting Area of the ER Program that corresponds to the sum of annual change in carbon stocks and removals for each of i REDD+ activities at year t; tCO_2*year^{-1}.
T	=	Number of years during the monitoring period; dimensionless.

Annual change in total biomass carbon stocks forest land converted to another land-use category ($\Delta C_{B_{defo,t}}$)

The annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta \mathbf{C}_{\mathbf{B}_{defo,t}}$) would be estimated through **Equation 4** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_t} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) \text{ x CF x} \frac{44}{12} \times A(j,i)_{RP}$$ ***Equation 10*** (Equation 2.16, 2006 IPCC GL)

Where:

$A(j,i)_{RP}$ Area converted/transited from forest type j to non-forest type *i* during the Reference Period, in hectares per year. In this case, twenty-four forest land conversions are possible:

1 Agro-forest to Cocoa
2 Agro-forest to Grassland
3 Agro-forest to Human settlement
4 Agro-forest to Other crops
5 Agro-forest to Other lands
6 Agro-forest to Perennial crops
7 Dense Forest to Cocoa
8 Dense Forest to Grassland
9 Dense Forest to Human settlement
10 Dense Forest to Other crops
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12 Dense Forest to Perennial crops
13 Forest plantations / reforestation to Cocoa
14 Forest plantations / reforestation to Grassland
15 Forest plantations / reforestation to Human settlement
16 Forest plantations / reforestation to Other crops
17 Forest plantations / reforestation to Other lands
18 Forest plantations / reforestation to Perennial crops
19 Secondary Forest to Cocoa
20 Secondary Forest to Grassland
21 Secondary Forest to Human settlement
22 Secondary Forest to Other crops
23 Secondary Forest to Other lands
24 Secondary Forest to Perennial crops

$B_{Before,j}$ Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground ($AGB_{Before,j}$) and belowground biomass ($BGB_{Before,j}$) and it is defined for each forest type.

$B_{After,i}$ Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest IPCC Land Use categories.

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.

$44/12$ Conversion of C to CO_2

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta \boldsymbol{C}_{\boldsymbol{B}_{\boldsymbol{deg,t}}}$)

The Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta \boldsymbol{C}_{\boldsymbol{B}_{\boldsymbol{deg,t}}}$) would be estimated through **Equation 7** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta \boldsymbol{C}_{\boldsymbol{B}_{\boldsymbol{DEG}}} = \sum_{\boldsymbol{j}} \{ \boldsymbol{EF}_{\boldsymbol{j}} \times \boldsymbol{A}(\boldsymbol{a},\boldsymbol{b})_{\boldsymbol{MP}} \}$$ **Equation 11**

Where:

$\mathbf{EF_j}$	Emission factor for degradation of forest type a to forest type b, tones CO2 ha^{-1}.
$\boldsymbol{A(a,b)_{MP}}$	Area of forest type a converted to forest type b (transition denoted by a,b) during the Monitoring Period, ha yr^{-1}.

Annual change in carbon stocks in biomass on non-forestland converted in forestland ($\Delta \boldsymbol{C_{B_{reg}}}$)

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta \boldsymbol{C_{B_{reg}}}$) would be estimated through **Equation 8** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

:

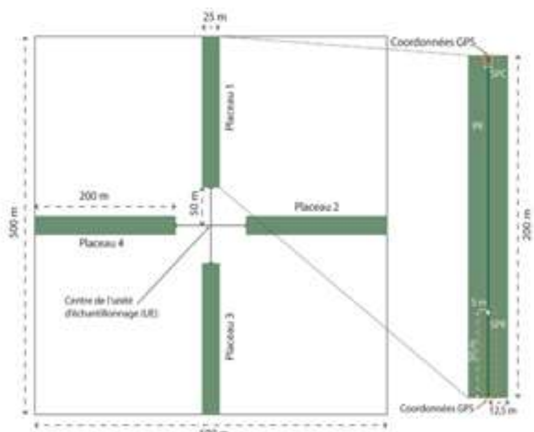
$$\Delta C_{B_{reg}} = \sum_{LU=1}^{n} \left\{ RF_{reg} \times A(i,j)_{MP} \right\}$$ **Equation 12**

Where:

$\boldsymbol{RF_{reg}}$	enhancement of carbon stocks in new forests [tCO2*ha*$year^{-1}$].
$\boldsymbol{A(j,i)_{MP}}$	Area of non-forestland *i* converted to forestland *j* (transition denoted by *i,j*) in the Monitoring Period, ha yr^{-1}.
$\boldsymbol{LU}$	Land unit.

3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

Parameter:	$AGB_{Before,j}$
Description:	*Aboveground biomass of forest before conversion,*
Data unit:	*ton of dry matter per ha*
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The data used in this document are from Tier 2 level (country-specific data) and come from the National Forest Inventory of 2017 for forests (dense forest and secondary forest in the ombrophilic sector; dense forest and secondary forest in the mesophilic sector). All NFI data and script can be found here. Each teaching unit has 4 plots, for a total of 600 plots. The data are sufficiently representative of the program area and allowed accurate estimates of emission factors. The biomass of forest strata before conversion was obtained using a 3-phase approach: (i) sampling plan development, (ii) field data collection and (iii) biomass estimation. **i. Sampling plan** The sampling plan adopted for collecting forest biomass data in Côte d'Ivoire is stratified random and was based on the country's phytogeographical zoning (ombrophilous, Mesophilic, pre-forest and Sudanese). This sampling technique has several advantages, including (i) the elimination of any subjectivity in the choice of sampling units to be measured, (ii) the calculation of parameters per stratum and of the distinct sampling error for certain strata, and (iii) the reduction of the variability of a parameter of a given stratum. Sampling units are available via this link. are clusters of 500 m x 500 m consisting of four rectangular observation plots of 25 m x 200 m. Each SU thus covers an area of 25 hectares. The coordinates of the centre of these units correspond to the coordinates of the points on the survey plan. Once the centre of the SU is located and established, the four plots are set up inside the SU and arranged in a cross pattern. They are each located 50 m from the centre of the SU and are numbered clockwise from 1 to 4.  figure 2: Sampling unit

The forest strata resulting from the inventory are recorded in the table below:

IPCC Category	Phytogeographic zones	Forest class
Forest land	Ombrophilous	Dense forest
		Secondary forest
	Mesophilic	Dense forest
		Secondary forest

ii. Data gathering

A three-level collection system is implemented within each SU, corresponding to three different levels of readings:

- level 1 consists of four rectangular plots of 25 m x 200 m each intended for measuring trees with a DBH ≥ 10 cm, standing, dead wood standing, dead wood lying on the main strip (axis of the plot);
- Level 2 consists of a rectangular sub-plot of 10 mx 50 m each located inside each rectangular space. It is intended for measuring trees with small diameters (5 cm ≤ DBH < 10 cm);
- Level 3 consists of a square sub-plot of 5 m x 5 m in each plot and intended for the assessment of biodiversity (count of individuals of woody species with DBH < 5 cm and height ≥ 1.30 m).

For levels 1 and 2, the measurements related to the height, the diameter at breast height (DBH = 1.30 m) and observations on the health status of the tree. The diameter of lying dead wood was measured on the 200 m of the main section of the plot (level 1). For level 3, observations focused on the presence or absence of woody species whose total height is greater than or equal to 1.30 m and diameter less than 5 cm.

The details of the collection method can be viewed from the following link.

iii. Estimation of above-ground biomass (AGB) at the sample level

The pantropical allometric equation developed by Chave et al. (2014) was used to convert field measurements into estimates of aboveground biomass (AGB) because it is considered more robust (s= 0.357; Akaike Information Criterion (AIC)=3130 and df=4002), recent and covers a wide range of vegetation types, for a total of 4004 trees ranging in trunk diameter from 5 cm to 212 cm, and includes data from other pantropical equations including Brown's equation (1997), the Chave (2005) and that of Fayolle (2013).

Model 4 of the Chave et al. (2014) was used for biomass estimates. It is based on the diameter at breast height (DBH), the height of the tree and the basic density of the wood. The mathematical expression of this allometric equation is:

$$AGB = 0.0673 \times (r\ DHP2\ H)0.976$$

Where :

- AGB is the estimated aboveground biomass in Kg;
- D is the diameter at breast height in cm;
- H is the total height of the tree (m);
- r is the specific density of the wood (g.cm-3)

Value applied:	The Aboveground Biomass for the forest land category from the NFI are recorded in the following table

Phytogeographic zone	Forest land category	AGB
		tdm/ha
Mesophilic	Dense forest	134.70
	Secondary forest	67.88
Ombrophilous	Dense forest	204.57
	Secondary forest	107.71

The Aboveground Biomass Spreadsheet can be viewed via this link and all carbon densities here.

QA/QC procedures applied

To ensure data quality, the following QA/QC procedures were applied:

- Design of a field data collection manual to serve as a guide. The manual can be viewed from the following link;
- Training of collection teams;
- Collection of field data in 2 formats, paper (field sheet) and digital (tablets on which the Collect tool of the Open Foris platform has been installed;
- Verification of the conformity of the data collected in the field sheets and tablets;
- Constitution of 2 mixed teams for the verification on the ground of 8% of the total of the formed sampling units. These teams were made up of SEP-REDD+, universities and research centres and civil society organizations.

This control consisted in carrying out measurements on 8% of all the SUs in order to make comparisons with the measurements collected by the collection teams. In each SU, a plot is randomly selected and information such as plot dimensions, type of occupation and land use, DBH and height and species names were recorded.

This information made it possible to correct some gaps.

- **Clearance and aggregation**

The information contained on the sheets and in the tablets was checked after the field phase to ensure their compliance and consistency. The field sheets have been digitized and archived. These files can be consulted here. Then, a cross between the 2 information sources made it possible to correct the names of the species, the input errors, the omissions and the commissions in the recording of the data. These operations resulted in a final database, which was used for the calculations of emission factors.

Uncertainty associated with this parameter:	Uncertainties in above-ground biomass (AGB) estimates for dense and secondary forests

	Above ground biomass (AGB)			
	Dense forest		Secondary forest	
Parameter	Ombrophilous	Mesophilic	Ombrophilous	Mesophilic
Standard error [tdm/ha]	17.44	12.91	9.11	5.60
Absolute error [tdm/ha]	29.83	22.74	15.52	9.62
Relative error [%]	14.58	16.88	14.41	14.17

Any comment:	

Parameter:	BGB $_{Before,j}$
Description:	Belowground biomass of category forest j before conversion
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Belowground biomass is calculated by applying the stem to root ratio on AGB for tropical forest as reported in Table 4.4 IPCC 2006 vol 4 (IPCC, 2006).
Value applied:	See table below

Forest land category	**BGB**
	tdm/ha
dense mesophilic forest	30.60
Mesophilic secondary forest	13.58
Dense Rainforest	75.69
Secondary rain forest	39.85

The spreadsheet can be viewed here.
All resources (spreadsheets, script and input data) are available here.

<table>
<tr><td>QA/QC procedures applied</td><td>Refer to the QA/QC process of AGB before j</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>Uncertainties in belowground biomass estimates for dense and secondary forests

<table>
<tr><td></td><td colspan="4">Below-ground biomass (BGB)</td></tr>
<tr><td></td><td colspan="2">Dense forest</td><td colspan="2">Secondary forest</td></tr>
<tr><td>Parameter</td><td>Ombrophilous</td><td>Mesophilic</td><td>Ombrophilous</td><td>Mesophilic</td></tr>
<tr><td>Standard error [tdm/ha]</td><td>6.45</td><td>3.46</td><td>3.37</td><td>1.12</td></tr>
<tr><td>Absolute error [tdm/ha]</td><td>11.04</td><td>6.09</td><td>5.74</td><td>1.92</td></tr>
<tr><td>Relative error [%]</td><td>14.58</td><td>19.92</td><td>14.41</td><td>14.17</td></tr>
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<tr><td>Any comment:</td><td></td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>$AGB_{After,i}$</td></tr>
<tr><td>Description:</td><td>Aboveground biomass of the cropland category: cocoa
In Côte d'Ivoire, the main driver of deforestation is agriculture, with cocoa production being the lead driver. Forests are largely converted to cocoa plantations, especially in the ER-Program area.</td></tr>
<tr><td>Data unit:</td><td>Ton of dry matter per hectare</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>The biomass for cocoa plantations comes from the study by N'Gbala et al., (2017).
Following an inventory carried out in cocoa plantations in the central western zone of the country, they used the diameter measurements at 30 cm from the ground (because cocoa trees generally branch off below 1.30 m) in the allometric equation de Segura et al., (2005), to determine the above-ground biomass of cocoa plantations. The article can be viewed via this link.</td></tr>
<tr><td>Value applied:</td><td>
<table>
<tr><td colspan="2">AGB</td></tr>
<tr><td rowspan="2">Cocoa</td><td>tdm/ha</td></tr>
<tr><td>37.2</td></tr>
</table></td></tr>
</table>

QA/QC procedures applied	The above-ground biomass of cocoa plantations considered in this work (37.2 tdm/ha) is taken from the study by N'Gbala et al., (2017) see. the full study can be viewed here. This value more or less coincides with that of the study conducted by Nimo et al, (2021) in Ghana. Fully publication can be viewed by the following link. In their study, they estimated the aboveground biomass of cocoa plantations at 32.02 tdm/ha using the same methodological approach. This difference of about 5 tdm/ha between these two studies could be explained by the difference in age of the inventoried plantations, 26 years and 20 years respectively for N'gbala et al, (2017) and Nimo et al, (2021). Thus, with the addition of local context considerations, the value retained (37.2 tdm/ha) is considered relevant as a value of (above-ground) biomass for cocoa plantations in the ERP area.
Uncertainty associated with this parameter:	AGB: SE (standard error) 2.9; 90% CI [tdm/ha] 4.77; 90% CI [%] 13.34
Any comment:	

AGB	
SE (standard error)	2.9
90% CI [tdm/ha]	4.77
90% CI [%]	13.34

Parameter:	BGB $_{After,i}$
Description:	Category Belowground Biomass: Cocoa
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The underground biomass for cocoa plantations comes from the study by N'Gbala et al. (2017). This study applied the allometric model r2 = 0.84 developed by Cairns et al., (1997) and widely used by a number of authors (Somarriba et al., 2013). This model is an accepted methodology within the framework of the IPCC on land use, land use change and forestry (Penman et al., 2003).
Value applied:	BGB: Cocoa, tdm/ha 8.2
QA/QC procedures applied	This data from the literature has been re-evaluated by the MRV team in Côte d'Ivoire, which confirms that the values are consistent with those of the program area.

BGB	
Cocoa	**tdm/ha**
	8.2

<table>
<tr><td>Uncertainty associated with this parameter:</td><td><table><tr><td colspan="2">BGB</td></tr><tr><td>SE (standard error)</td><td>0.6</td></tr><tr><td>90% CI [tdm/ha]</td><td>0.99</td></tr><tr><td>90% CI [%]</td><td>12.52%</td></tr></table></td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>$AGB_{After,i}$</td></tr>
<tr><td>Description:</td><td>Aboveground biomass of the category: Perennial crop
The category of land of the perennial crop type essentially includes agricultural commodities other than cocoa that are practiced in the ER-Program area. These are particularly rubber and palm oil;<table><tr><td>Category</td><td>Subclass</td></tr><tr><td rowspan="2">Perennial crop</td><td>rubber tree</td></tr><tr><td>Oil palm tree</td></tr></table></td></tr>
<tr><td>Data unit:</td><td>Ton of dry matter per hectare</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>The biomass for the perennial crop category is derived from the average biomass of rubber and oil palm plantations. The data for each of them are taken from the literature. These are regional studies carried out in Ghana.
Grieco et al., (2012) used information from an inventory in samples of rubber and oil palm plots. They used the sampling protocol used to detect changes in the aboveground biomass carbon pool proposed by the FAO: Assessing carbon stocks and modelling win-win scenarios of carbon sequestration through land-use changes. (Ponce Hernandez, 2004). The average age of plantations considered in this study of 10 years and 20 years respectively for rubber and oil palm.
The study by Grieco et al., (2012) can be consulted from the link and complete Ponce Hernandez, (2004) study from this link.</td></tr>
<tr><td>Value applied:</td><td><table><tr><td colspan="2">AGB</td></tr><tr><td rowspan="2">Perennial crop</td><td>tdm/ha</td></tr><tr><td>86.7</td></tr></table></td></tr>
<tr><td>QA/QC procedures applied</td><td>According to Grieco et al. (2012) each of the crops (rubber and oil palm) have their above-ground biomass estimated in the study: 113.4 tdm for rubber and 60 tdm for oil palm. The relevance of using the average of these values including the applied value has been verified and confirmed by the MRV team in Côte d'Ivoire.</td></tr>
</table>

Uncertainty associated with this parameter:	AGB: SE (standard error) 15.20; 90% CI [tdm/ha] 25; 90% CI [%] 28.84
Any comment:	

AGB	
SE (standard error)	15.20
90% CI [tdm/ha]	25
90% CI [%]	28.84

Parameter:	BGB $_{After,i}$
Description:	Belowground biomass of the category: Perennial crop The category of land of the perennial crop type essentially includes agricultural commodities other than cocoa that are practiced in the ER-Program area. These are particularly rubber and palm oil;
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Belowground biomass was calculated by applying the AGB stem-to-root ratio (Cairns et al., 1997; Mokany et al., 2006) considering that the underground biomass represents 20% of the aboveground biomass. All this information can be found in Grieco et al., (2012). Mokany et al (2006) complete study can be viewed by the following link.
Value applied:	BGB – Perennial crop: 17.4 tdm/ha
QA/QC procedures applied	According to Grieco et al. (2012) each of the crops (rubber and oil palm) had its underground biomass estimated in the study: 22.8 tdm for rubber and 12 tdm for oil palm. The relevance of using the average of these values including the applied value has been verified and confirmed by the MRV team in Côte d'Ivoire.
Uncertainty associated with this parameter:	See table below

Category	Subclass
Perennial crop	rubber tree
	Oil palm tree

BGB	
Perennial crop	**tdm/ha**
	17.4

BGB	
SE (standard error)	3.02
90% CI [tdm/ha]	4.97
90% CI [%]	28.58

Any comment:	

Parameter:	$AGB_{After,i}$
Description:	Aboveground biomass of category: Grassland In the ERP area, the grassland category consists mainly of shrublands as described in the land use class nomenclature available here.
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The data of the biomass for the grass category is taken from a regional study (Ilboudo, 2018) conducted in Burkina Faso (located north of Côte d'Ivoire). The author used inventory data (diameter at breast height and height measurements) in sample units to estimate the above-ground biomass of the grassland category using polynomial allometric equations (Mbow, 2009).
Value applied:	<table><tr><th colspan="2">AGB</th></tr><tr><td rowspan="2">grassland</td><td>tdm/ha</td></tr><tr><td>35.33</td></tr></table>
QA/QC procedures applied	The QA/QC procedure consisted of evaluating the differences between the applied value from Ilboudo (2018) and what has been done elsewhere by other authors. Thus, Amougou et al. (2016) obtained values close to Ilboudo (2018) in their study conducted on the carbon stock estimate in two land units in the savannah zone of Cameroon, available at this link. The results obtained were 15.47 tdm/ha and 32.58 tdm/ha. These values, slightly different from those of Ilboudo (2018), can be explained by the use of different allometric equations and the specificity of the different plant species. The values of these two studies being noticeably close, that of Ilboudo was retained because of the similar regional context with Côte d'Ivoire.
Uncertainty associated with this parameter:	<table><tr><th colspan="2">AGB</th></tr><tr><td>SE (standard error)</td><td>44.09</td></tr><tr><td>90% CI [tdm/ha]</td><td>72.53</td></tr><tr><td>90% CI [%]</td><td>205.29</td></tr></table>
Any comment:	

Parameter:	BGB $_{After,i}$
Description:	Belowground Biomass Category: Grassland
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Belowground biomass was calculated by applying the AGB stem-to-root ratio (Cairns et al., 1997). According to Cairns et al., 1997 study, belowground biomass can be calculated from aboveground biomass using a global model that they developed for forest root biomass estimation from total aboveground biomass. The study found that below-ground biomass accounts for about 26% of the total biomass. Complete study is available at this address.
Value applied:	**BGB** — **grassland**: **tdm/ha** 4.55
QA/QC procedures applied	See AGB grassland
Uncertainty associated with this parameter:	**BGB**: SE (standard error) 4.82; 90% CI [tdm/ha] 7.93; 90% CI [%] 174.26
Any comment:	

Value applied:

BGB	
grassland	**tdm/ha**
	4.55

Uncertainty:

BGB	
SE (standard error)	4.82
90% CI [tdm/ha]	7.93
90% CI [%]	174.26

Parameter:	*AGB $_{After,j}$*
Description:	Above-ground biomass of the agroforest category
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the	The biomass for cocoa-based agroforests comes from the study by Asigbaase et al., (2021), available at this link. In their methodological approach, they relied on an inventory of different agroforestry systems in Ghana. Using diameter at breast height (DBH) measurements in the allometric equation of Chave et al., (2014) for shade trees and Andrade et al., (2008) for cocoa.

spatial level of the data (local, regional, national, international):	
Value applied:	<table><tr><td></td><td>**AGB**</td></tr><tr><td rowspan="2">**agroforest**</td><td>**tdm/ha**</td></tr><tr><td>45.8</td></tr></table>
QA/QC procedures applied	A literature review carried out on the theme related to the quantification of agroforestry systems was carried out in order to confirm our choice of the value applied above. Thus, taking the same approach in Ghana, Nimo et al., (2021) showed that agroforestry systems store around 74 tdm/ha. This difference results from the diversity of the forest species used but especially from the difference of the allometric equations.
Uncertainty associated with this parameter:	<table><tr><th colspan="2">AGB</th></tr><tr><td>SE</td><td>2.6</td></tr><tr><td>90% CI [tdm/ha]</td><td>4.37</td></tr><tr><td>90% CI [%]</td><td>9.55</td></tr></table>
Any comment:	

Parameter:	$BGB_{After,j}$
Description:	Belowground biomass of the agroforest category
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Belowground biomass was calculated by applying the AGB stem-to-root ratio (Cairns et al., 1997). The article is available at the following link.
Value applied:	<table><tr><td>**BGB**</td></tr></table>

	agroforest — tdm/ha: 8.4
QA/QC procedures applied	See AGB table agroforest
Uncertainty associated with this parameter:	BGB: SE 0.66; 90% CI [tdm/ha] 1.11; 90% CI [%] 13.22
Any comment:	

agroforest	tdm/ha
	8.4

BGB	
SE	0.66
90% CI [tdm/ha]	1.11
90% CI [%]	13.22

Parameter:	BGB $_{After,\ RFreg}$
Description:	Removals in the BGB due to carbon sequestration due to creation of forest plantation
Data unit:	Ton of dry matter per hectare per year (tdm/ha)
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The root shoot ratio developed by MOKANY, KAREL & Raison, RJ & Prokushkin, Anatoly in 2005 was used: Critical analysis of root: Shoot ratios in terrestrial biomes. Available at this address.
Value applied:	see table below

Category	BGB
	tdm/ha
Forest plantations / reforestation < 20 yrs	45.94
Forest plantations / reforestation > 20 yrs	100.8

QA/QC procedures applied	These data from the literature were confirmed by the MRV team in Côte d'Ivoire, which ensured the consistency of the values for the program area.
Uncertainty associated with this parameter:	<table><tr><th rowspan="2">Parameter</th><th colspan="2">BGB</th></tr><tr><th>Forest plantations / reforestation < 20 yrs</th><th>Forest plantations / reforestation > 20 yrs</th></tr><tr><td>90% CI [tdm/ha]</td><td>3.68</td><td>8.06</td></tr><tr><td>Relative error [%]</td><td>8</td><td>8</td></tr></table>
Any comment:	

3.2 Monitored Data and Parameters

Parameter:	$A(j, i)$
Description:	*Area converted from forest type j to non-forest type i during the reference period (2000-2015).*
Data unit:	*Hectare per year.*
Value monitored during this Monitoring / Reporting Period:	*Ombrophile zone* *Table 1: Annual deforestation and degradation (ha/ year) in the ombrophile zone between 2000-2015*

Deforestation	*From Dense Forest (DF) to Cocoa Crops (CC)*	*7337,16*
	From Dense Forest (DF) to Perennial Crops (PC)	*40,58*
	From Dense Forest (DF) to Other Crops (OC)	*1649,72*
	From Dense Forest (DF) to Grassland (GG)	*1258,74*
	From Dense Forest (DF) to Human Settlement (HH)	*40,58*
	From Secondary forest *(SF) to Cocoa Crops (CC)*	*9277,40*
	From Secondary Forest (SF) to Perennial Crops (PC)	*1324,00*
	From Secondary Forest (SF) to Other Crops (OC)	*2663,89*
	From Secondary Forest (SF) to Grassland (GG)	*1428,39*
	From Secondary Forest (SF) to Human Settlement (HH)	*62,27*
	From Secondary Forest (SF) to Other Lands (OL)	*0,00*
Degradation	*From Dense Forest (DF) to Secondary Forest (SF)*	*5490.94*
	From Dense Forest (DF) to Forest Plantation (PP)	*0,00*
	From Dense Forest (DF) to Agroforest (AF)	*449,17*
	From Secondary Forest (SF) to Agroforest (AF)	*1627,94*
	From Secondary Forest (SF) to Dense Forest (DF)	*141,89*

Mesophile zone

Table 2: Annual deforestation and degradation (ha/ year) in the mesophile zone between 2000-2015

Deforestation	*From Dense Forest (DF) to Cocoa Crops (CC)*	*2090,77*
	From Dense Forest (DF) to Perennial Crops (PC)	*0,00*
	From Dense Forest (DF) to Other Crops (OC)	*275,43*
	From Dense Forest (DF) to Grassland (GG)	*350,64*
	From Dense Forest (DF) to Human Settlement (HH)	*00,00*
	From Dense Forest (DF) to Other Lands (OL)	*41,67*
	From Secondary Forest (SF) to Cocoa Crops (CC)	*3891,34*
	From Secondary Forest (SF) to Perennial Crops (PC)	*179,02*
	From Secondary Forest (SF) to Other Crops (OC)	*1605,26*
	From Secondary Forest (SF) to Grassland (GG)	*1109,14*
	From Secondary Forest (SF) to Human Settlement (HH)	*41,67*
	From Secondary Forest (SF) to Other Lands (OL)	*137,35*
Degradation	*From Dense Forest (DF) to Secondary Forest (SF)*	*1084,71*
	From Dense Forest (DF) to Forest Plantation (PP)	*0,00*
	From Dense Forest (DF) to Agroforest (AF)	*350,64*
	From Secondary Forest (SF) to Agroforest (AF)	*649,76*

Table 3: Forest gain (ha) between 2000-2010 and 2010-2015

	2000-2010	*2010-2015*	
Ombrophile zone			
Secondary forest (SF)	*2128*	*3369*	
Agroforest (AF)	*-*	*9126*	
Mesophile zone			
Secondary forest (SF)	*1250*	*3936*	
Agroforestry (AF)	*1753*	*8056*	

<table>
<tr>
<td>Source of data and description of measurement/ calculation methods and procedures applied:</td>
<td>
The activity data used for the reference period was obtained from a sampling approach for estimating areas that incorporates the following characteristics:
A sufficiently dense and balanced sample size to capture changes in land cover classes.
Hybrid machine (algorithm) / human (visual) interpretation to assign land cover classes and changes: Several change detection algorithms, from several sources of satellite images and/or other spatially explicit information and visual interpretation were used to detect change classes.
Cross-validation principle, both for machine interpretation (convergence of evidence) and human interpretation (elimination of subjective bias). This required the formalization of decision rules.
Quality control and integrated quality assurance at all stages of the process.
5. The FAO technical team in charge of forest monitoring has developed tools to facilitate the design and implementation of this approach. All these tools and resources are available via this link:

The figure below shows the different stages of the process:

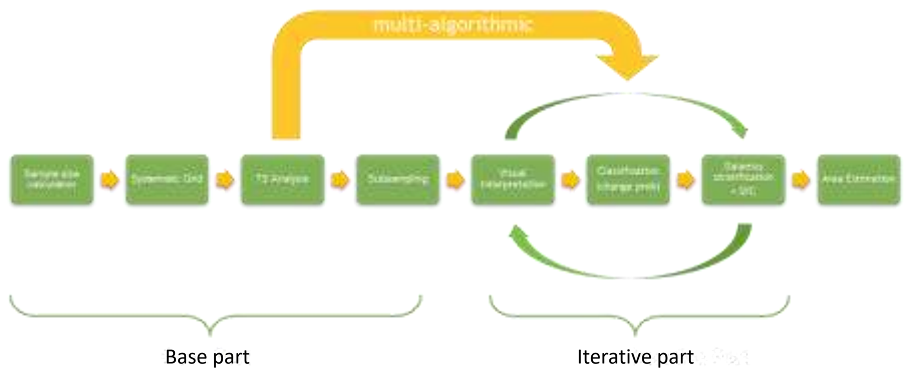


Figure 3: Steps in the methodological process for estimating activity data

Sampling design
An empirical analysis with a reference product (ESA CCI map 2015-2020) shows that a systematic sampling of 1km x 1km over the ERP area is required to capture the changes with a relative sampling error of less than 15% on the land cover change classes.
On this basis a rectangular systematic grid of 46,415 points was generated as illustrated in the figure below. The tool erp_01_sbae_design was developed to generate the samples.
</td>
</tr>
</table>

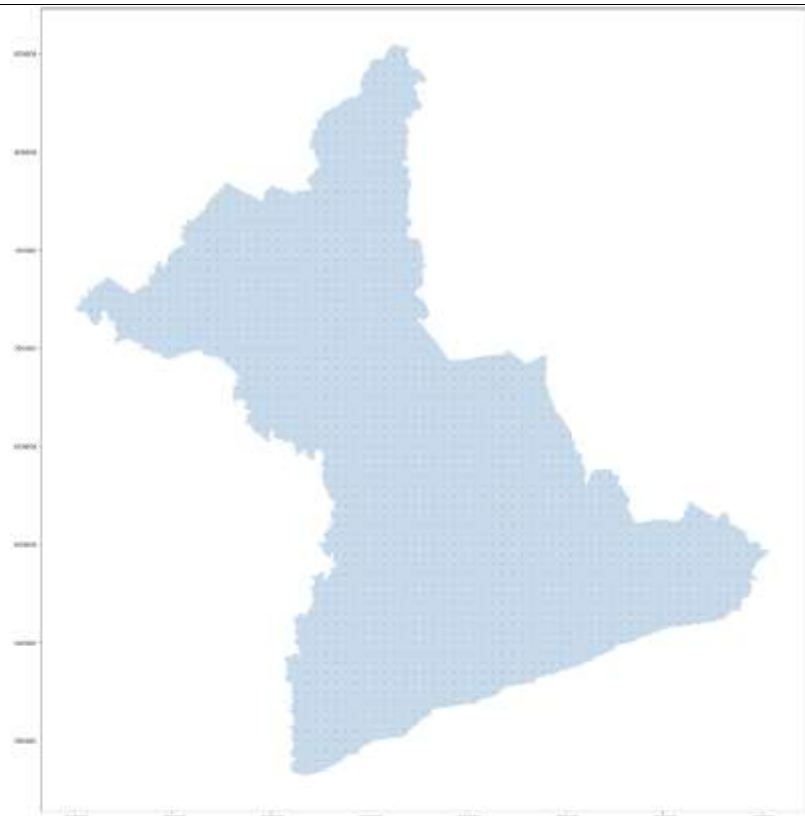


Figure 4: 1 sqkm grid adapted in the ERP

This established sampling system is stable over time and can be re-used for the regular updating of land cover change statistics.

Extraction of data (variables) from the assembly approach

Information from several global layers (TMF, GFC, ESA, DW, ESRI) is extracted for each of the points, as well as the normalized vegetation indices, from the entire Landsat archive. These index series are also analyzed with several algorithms (BFAST, CUSUM, CCDC, LandTrendR, and standard statistical descriptors). The list of variables used for this set approach is shown in the following table. These operations were performed using the notebook [erp_02_extract_ts.]

Name	Variables	Description	Reference	Link
Grid information	LON', 'LAT', 'PLOTID'	Coordinates and unique identifier of each point	Grid information	https://github.com/sepal-contrib/sbae_point_analysis
SRTM DEM	aspect', 'elevation', 'slope'	Digital elevation model variables	Farr et *al.* 2007	https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2005RG000183

	Dynamic World	dw_class_mode', 'dw_tree_prob__max', 'dw_tree_prob__min', 'dw_tree_prob__stdDev', 'dw_tree_prob_mean'	Dominant Dynamic World land cover class and tree probabilities	Brown et *al.*, 2022	https://www.nature.com/articles/s41597-022-01307-4
	ESA LC 2020	esa_lc20'	Global land cover product at 10 m resolution for 2020 based on Sentinel-1 and 2 data	Zanaga et *al*. 2021	https://worldcover2020.esa.int/
	ESRI LC 2020	esri_lc20'	Sentinel-2 10m land cover time series of the world from 2017-2021	Karra, et *al*. 2021	https://www.arcgis.com/home/item.html?id=d3da5dd386d140cf93fc9ecbf8da5e31
	GFC	gfc_gain', 'gfc_loss', 'gfc_lossyear', 'gfc_tc00'	Global Forest Change variables	Hansen et al. 2013	https://earthenginepartners.appspot.com/science-2013-global-forest
	Canopy height model	lang_tree_height'	Tree height	Lang et al., 2022	https://arxiv.org/abs/2204.08322
	Forest canopy height	potapov_tree_height'	Tree height	Potapov et al., 2020	https://www.sciencedirect.com/science/article/pii/S0034425720305381
	TMF	tmf_20xx' .. 'tmf_20yy', 'tmf_defyear', 'tmf_degyear', 'tmf_main', 'tmf_sub'	Tropical Moist Forest variables, including yearly land cover	Vancutsem et al., 2021	https://www.science.org/doi/10.1126/sciadv.abe1603
	Landsat Time series	dates', 'ts', 'images', 'mon_images'	Dates, spectral values and total number of USGS Landsat 4 to 9 acquisitions, Level 2, Collection 2, Tier 1	USGS, 2008	https://www.usgs.gov/landsat-missions/landsat-collection-2-level-1-data
	CCDC	ccdc_change_date', 'ccdc_magnitude'	Continuous change detection and classification of land cover using all available Landsat data	Zhu and Woodock, 2014	https://www.sciencedirect.com/science/article/pii/S0034425714000248
	LandTrendR	ltr_magnitude', 'ltr_dur', 'ltr_yod', 'ltr_rate', 'ltr_end_year'	Temporal segmentation for forest disturbance and recovery	Kennedy et al., 2010	https://www.sciencedirect.com/science/article/pii/S0034425710002245
	BFAST	bfast_change_date', 'bfast_magnitude', 'bfast_means'	Near real-time disturbance detection using satellite image time series	Verbesselt et al., 2013	https://www.sciencedirect.com/science/article/pii/S0034425712001150?via%3Dihub

CUSUM	cusum_change_date', 'cusum_confidence', 'cusum_magnitude'	Cumulative Sum Test to Detect Land-Cover Changes	Kellndorfer, etal. 2019	https://gis1.servirglobal.net/TrainingMaterials/SAR/Ch3-Content.pdf
TS metrics	ts_mean', 'ts_sd', 'ts_min', 'ts_max'	Basic statistical metrics describing the time series	Vollrath, unpublished	https://github.com/sepal-contrib/sbae_point_analysis
Bootstrap	bs_slope_mean', 'bs_slope_sd', 'bs_slope_max', 'bs_slope_min'	Basic statistical metrics describing the trend of the time series	Vollrath, unpublished	https://github.com/sepal-contrib/sbae_point_analysis

Using the tool erp_02_extract_ts.made it possible to associate the information above with each sample.

Unsupervised aggregation of points

The information is injected into a cluster model that identifies points with similar trajectories for the different products. The clusters have different sizes, and correspond to homogeneous groupings of points, a priori distinguishing between change points and stable points. The goal is to make an unsupervised classification of the information on the points, to have different a priori batches of points with different trajectories of change. This allows points to be selected from all clusters to have a representative training dataset to be interpreted.

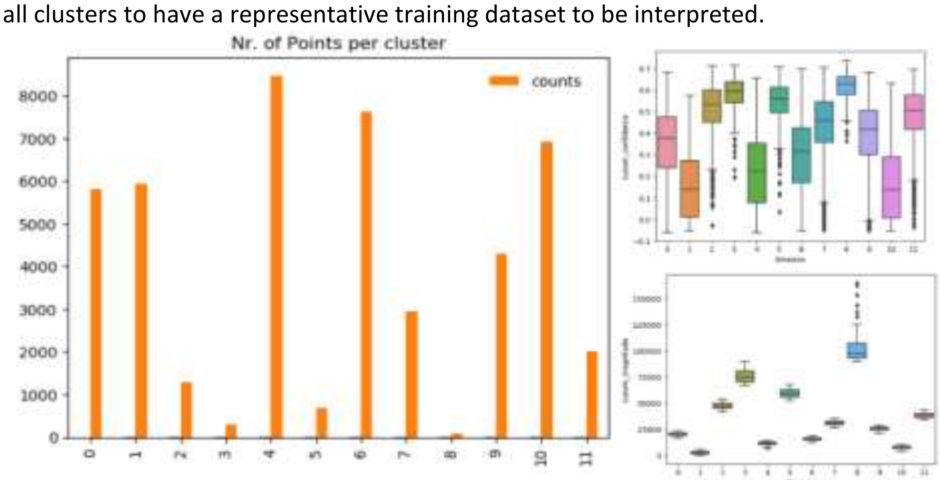


Figure 5 : Unsupervised cluster analysis (12 clusters 30 pts max / cluster 339 points)

The next step is to draw a small number of points (here ~30) in each of the clusters (339 in total) to produce a training dataset with descriptive variables of land use status and trends. https://app.collect.earth/collection?projectId=32912

A project has been generated to collect this information by visual interpretation.

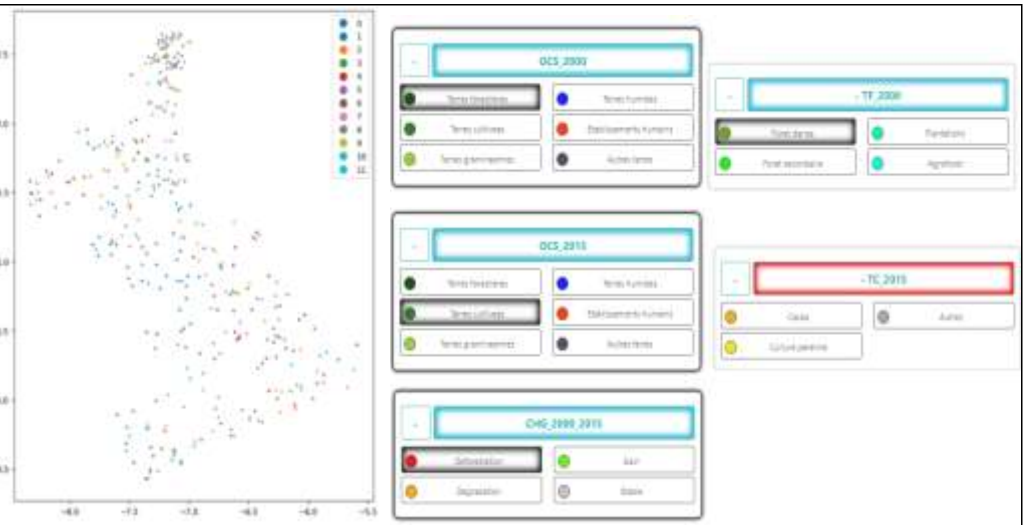


Figure 6: First interpreted dataset and survey form.

The collection of this reduced set of points is also an opportunity to check the robustness of the [interpretation keys.](#)

Supervised classification 1

CLUSTER	0	1	2	3	4	5	6	7	8	9	10	11
Deforestation	8	5	10	11	14	8	1	16	3	10	15	12
Degradation	1	0	1	1	0	0	2	0	0	1	0	0
Stable	21	25	19	18	16	22	27	14	6	19	17	18
Prop. Defor.	27%	17%	33%	37%	47%	27%	3%	53%	33%	33%	43%	40%
Total	7298	4372	1874	7617	1865	129	6187	8657	9	2953	5800	454

```
Maximum probability of stable for change points
0.8421333333333332
Reasonable probability of stable for change points
0.4904000000000006
Number of points above thshld (considered stable)
235 out of 339
Number of actual change points left in stable
11
```

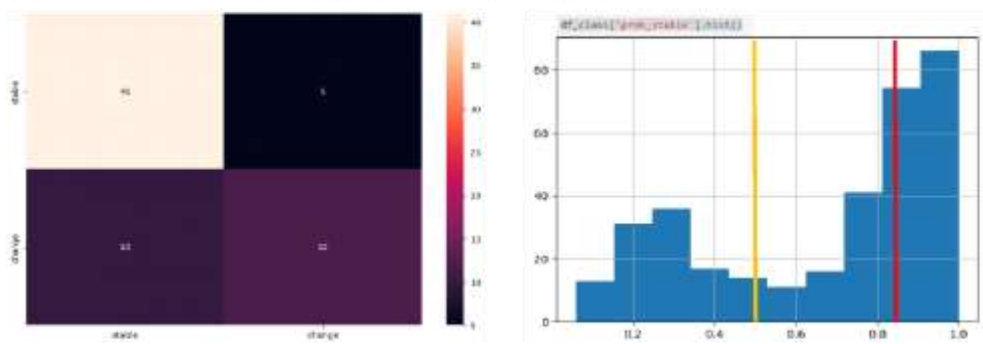


Figure 7 : Distribution of probabilities of being stable in the interpreted data set (339 points)

The data is then used to perform a supervised classification of the set of points with respect to land use change types.

Figure 7 illustrates the results of the supervised classification with two classes (deforestation and stable), through the distribution of the probabilities of being stable, for each of the 339 points. The red bar indicates the probability threshold (0.84) beyond which no change points were recorded and the yellow bar indicates the 90% percentile (probability of 0.49). The 339 sample points were considered statistically insufficient to represent the entire sample.

To address this shortcoming a second training dataset with a number of points was determined based on the approach described by Hidiroglou, M.A. and Kozak, M. (2018) and Dalenius, T.

and Hodges Jr, J.L.(1957). It increases the precision of estimates by assigning different sampling fractions to strata. For this dataset, we have 692 samples (Figure 8).

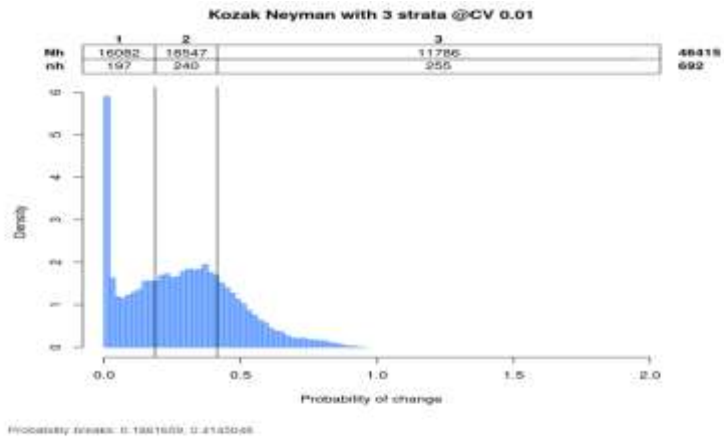


Figure 8: Change probability de changement according to Kozak Neyman

Supervised classification 2

The dataset of 692 points was interpreted according to the selection in the previous figure in order to serve as training for supervised classification using the *Random Forest* algorithm. This classification gives a good distribution and confirms the good representativeness of the 692 points in relation to the whole.

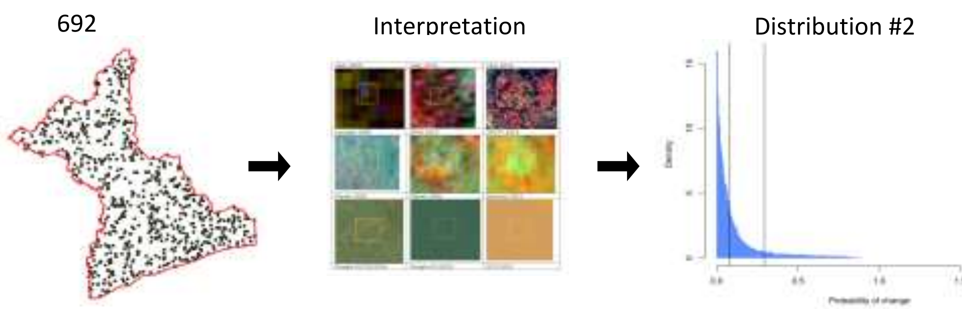


Figure 9: Supervised classification to achieve better class separation.

Final selection

Using the actual observed variance of the 692 points already interpreted, the combined Dalenius - Neyman method with 3 strata could be applied to arrive at the final selection of 3308 points, i.e. a total of 4000 points (with 692 points already interpreted) as illustrated in Figure 10. below.

These points were then interpreted in order to obtain the different classes of change in the ERP area over the period 2000 to 2021, thus covering the reference period (2000-2015) and the monitoring period (2020-2021).

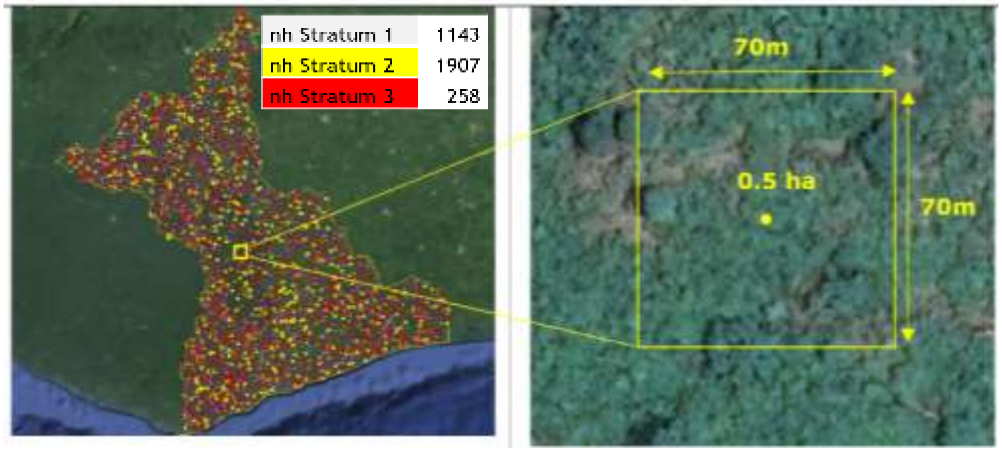


Figure 10 : Final Sample and exemple of a sample point

Sample Interpretation

The interpretation rules mentioned above were then presented and implemented during a workshop held in Paris, France from December 12 to 16, 2022 with the presence of IGN FI, World Bank and SEP REDD+ teams. This workshop helped harmonize the interpretations and reduce the margins of uncertainty. Following this workshop, all 4,000 selected points were interpreted. An analysis of the disagreements between interpretations was made possible by the double interpretation of the 692 points.

Following the analysis of the disagreements on the 692 points, it was necessary to perform a more thorough quality control in order to reduce the potential errors of interpretation as much as possible. Therefore, the points on which at least one change had been detected during the period 2000-2015 and 2020-2021 were reinterpreted representing 995 samples out of a total of 4,000.

Statistical analysis

All 4,000 samples, including those that were reinterpreted, were used as the basis for calculating area estimates and their uncertainty.

The estimation of activity data was done using the stratified random estimator based on the formulas described by Cochran (1977) and GFOI (2020). Estimates are made for each of the land use categories considered (11 classes) and in terms of changes from one period to another representing a total of more than 60 effective combinations.

Estimates and associated uncertainties are produced for each combination and for each phytogeographic zone (Mesophilic, Ombrophilic and Sub-Sudanian) considering the stratification applied. A detailed description of the calculation methods is available in the SOP_4_Data analysis_RCI.docx document.

QA/QC procedures applied:

The QA/QC procedures applied consisted of:

First, standard operating procedures (SOPs) were developed as described in section 2.1

Interpretation was done by highly qualified professionals from the *Institut Géographique Numérique Française à l'International* (IGN-FI based in France) who are specialized in the interpretation of land cover with satellite imagery.

	Also, a cross-interpretation of the first series of sample points (692) was carried out by expert photo-interpreters from IGN-FI who had not taken part in the first interpretation and the MRV experts from SEP REDD+. This step made it possible to assess the accuracy and bias of the photointerpretation to ensure better calibration. Following the analysis of the disagreements of the cross-interpretation, it appeared necessary to reinterpret a little less than 1000 samples in order to minimize the potential interpretation errors. The statistics associated with the different land use changes to determine the Activity Data were carried out by IGN-FI. The accuracy of the calculations and formulas used were independently verified by the FAO using an experienced statistician.
Uncertainty for this parameter:	*Quantification of uncertainties over the reference period (2000-2015)*

	Mesophile			**Ombrophile**		
Land cover change categories	**Estimation average (ha/an)**	**Confidence interval (CI) 90% (ha)**	**Confidence interval %**	**Estimation average (ha/an)**	**Confidence interval 90% (ha)**	**Confidence interval %**
Deforestation						
Agroforest (AF) to cocoa crops (CC)	621,15	461,34	73,76%	876,38	607,07	69,05%
Agroforest (AF) to Grassland (GG)	83,35	136,99	164,35%	81,15	133,38	164,35%
Agroforest (AF) to Other Crops (OC)	333,39	271,06	87,57%	263,62	336,96	127,39%
Agroforest (AF) to Human Settlement (HH)				81,15	94,28	116,18%
Dense Forest (DF) to Cocoa Crops (CC)	2090,77	792,79	45,20%	7337,16	1410,39	20,04%
Dense Forest (DF) to Perennial Crops (PC)				40,58	66,69	164,35%
Dense Forest (DF) to Other Crops (OC)	275,43	267,57	111,56%	1649,72	734,84	44,65%
Dense Forest (DF) to Grassland (GG)	350,64	364,21	69,25%	1258,74	611,60	48,15%
Dense Forest (DF) to Human Settlement (HH)				40,58	66,69	164,35%
Dense Forest (DF) to Other Land (OL)	41,67	68,49	164,35%			
Secondary Forest (SF) to Cocoa Crops (CC)	3891,34	1192,55	30,46%	9277,40	1882,44	20,86%
Secondary Forest (SF) to Perennial Crops (PC)	179,02	236,02	131,84%	1324,00	715,35	52,42%

Secondary Forest (SF) to Other Crops (OC)	1605,26	802,83	47,41%	2663,89	937,93	35,34%
Secondary Forest (SF) to Grassland (GG)	1109,14	649,22	61,56%	1428,39	713,18	49,05%
Secondary Forest (SF) to Human Settlement (HH)	41,67	68,49	164,35%	62,27	102,38	164,40%
Secondary Forest (SF) to Other Land (OL)	137,35	225,86	164,45%			
Degradation						
Dense Forest (DF) to Agroforest (AF)	350,64	319,54	94,26%	449,17	336,07	74,82%
Dense Forest (DF) to Secondary Forest (SF)	1084,71	675,55	72,34%	5490,94	1340,28	28,69%
Secondary Forest (SF) to Agroforest (AF)	649,76	536,57	81,51%	1627,94	887,69	58,69%

Gain			
2000-2010			
	Area (ha)	**Confidence interval 90% (ha)**	**Confidence interval (%)**
Ombrophile zone			
Secondary forest (SF)	*2128,35*	*3499.99*	*164.45*
Mesophile zone			
Secondary forest (SF)	*1250,22*	*1451.70*	*116,12%*
Agroforest (AF)	*1753.20*	*2120.26*	*120.94*

2010-2015			
	Area (ha)	**Confidence interval 90% (ha)**	**Confidence interval (%)**
Ombrophile zone			
Secondary forest (SF)	*3 368,75*	*2 520,55*	*74,82%*
Agroforest (AF)	*9 125,96*	*5 696,04*	*62,42%*
Mesophile zone			
Secondary forest (SF)	*3 935,53*	*3 825,39*	*97,20%*
Agroforest (AF)	*8 055,94*	*6 113,77*	*75,89%*

Any comment:	

<table>
<tr><td>Parameter:</td><td>A(j,i)</td></tr>
<tr><td>Description:</td><td>Area converted from forest type j to non-forest type i during the monitoring period (2020-2021).</td></tr>
<tr><td>Data unit:</td><td>Hectare per year</td></tr>
<tr><td>Value monitored during this Monitoring / Reporting Period:</td><td>
Ombrophile Zone
<table>
<tr><td rowspan="6">Deforestation</td><td>From Agroforest (AF) to Cocoa Crops (CC)</td><td>1217.32</td></tr>
<tr><td>From Agroforest (AF) to Other Crops (OC)</td><td>608.66</td></tr>
<tr><td>From Agroforest (AF) to Human Settlement (HH)</td><td>608.66</td></tr>
<tr><td>From Secondary Forest (SF) to Human Settlement (HH)</td><td>608.66</td></tr>
<tr><td>From Secondary Forest (SF) to Other Crops (OC)</td><td>608.66</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Degradation</td><td>From Dense Forest (DF) to Secondary Forest (SF)</td><td>2128.35</td></tr>
<tr><td rowspan="2">Gain</td><td>Agroforest (AF)</td><td>3085.55</td></tr>
<tr><td></td><td></td></tr>
</table>
Mesophile zone
<table>
<tr><td rowspan="4">Deforestation</td><td>From Agroforest (AF) to Cocoa Crops (CC)</td><td>625,11</td></tr>
<tr><td>From Agroforest (AF) to Other Crops (OC)</td><td>625,11</td></tr>
<tr><td>From Secondary Forest (SF) to Other Crops (OC)</td><td>2060,20</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Degradation</td><td>From Secondary Forest (SF) to Agroforest (AF)</td><td>2060,20</td></tr>
<tr><td>Gain</td><td>Agroforest (AF)</td><td>2060,20</td></tr>
</table>
</td></tr>
<tr><td>Source of data and description of measurement /calculation methods and procedures applied:</td><td>See description for the reference period</td></tr>
<tr><td>QA/QC procedures applied:</td><td>See description for the reference period</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>Quantification of uncertainties over the reference period (2020-2021)</td></tr>
</table>

	Mesophile			Ombrophile		
Land cover change categories	**Estimation average (ha/an)**	**Confidence interval 90% (ha)**	**Confidence interval %**	**Estimation average (ha/an)**	**Confidence interval 90% (ha)**	**Confidence interval %**
Deforestation						
Agroforest (AF) to cocoa crops (CC)	625,11	1 027	164,4%	1 217,32	1 414	116,2%
Agroforest (AF) to Other Crops (OC)	625,11	1 027	164,4%	608,66	1 000	164,3%
Agroforest (AF) to Human Settlement (HH)				608,66	1 000	164,3%
Secondary Forest (SF) to Other Crops (OC)	2 060,20	3 388	164,4%	608,66	1 000	164,3%
Secondary Forest (SF) to Human Settlement (HH)				608,66	1 000	164,3%
Degradation						
Secondary Forest (SF) to Agroforest (AF)	2 060,20	3 388	164,4%			
Dense Forest (DF) to Secondary Forest (SF)				2 128,35	3 500	164,4%
Gain						
cocoa crops (CC) to Agroforest (AF)	2 060,20	3 388	164,4%	3 085,55	2 589	83,9%

Any comment:

4 QUANTIFICATION OF EMISSION REDUCTIONS

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

Year of Monitoring/Reporting period *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)	Adjustment, if applicable (tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)
2016	7,692,979	1,779,971	-10,320	0	9,462,630
2017	7,692,979	1,779,971	-15,480	0	9,457,470
2018	7,692,979	1,779,971	-20,640	0	9,452,309
2019	7,692,979	1,779,971	-25,801	0	9,447,149
2020	7,692,979	1,779,971	-30,961	0	9,441,989
2021	7,692,979	1,779,971	-36,121	0	9,436,829
2022	7,692,979	1,779,971	-41,281	0	9,431,669
2023	7,692,979	1,779,971	-46,441	0	9,426,509
2024	7,692,979	1,779,971	-51,601	0	9,421,349
Total	69,236,809	16,019,741	-278,647	0	84,977,903

Excel table with FRL full calculation can be viewed at following link :

- Integration tool: available here ;
- Integration tools including Monte Carlo simulation: available here ;
- Integration tools including sensitivity analysis: available here.

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

Year of Monitoring/Reporting Period	Emissions from deforestation (tCO_{2-e}/yr)	If applicable, emissions from forest degradation (tCO_{2-e}/yr)*	If applicable, removals by sinks (tCO_{2-e}/yr)	Net emissions and removals (tCO_{2-e}/yr)
2016	2,991,895	1,413,143	-322,705	4,082,332
2017	2,991,895	1,413,143	-356,272	4,048,766
2018	2,991,895	1,413,143	-389,839	4,015,199
2019	2,991,895	1,413,143	-423,406	3,981,632
2020	2,991,895	1,413,143	-456,973	3,948,065
2021	677,974	583,513	-516,595	744,893
Total	15,637,448	7,649,226	-2,465,789	20,820,886

4.3 Calculation of emission reductions

	2016-2020	**2021**	**Total**

Total Reference Level emissions during the Monitoring Period (tCO_2-e)	47,261,547	9,436,829	56,698,376
Net emissions and removals under the ER Program during the Monitoring Period (tCO_2-e)	20,075,993	744,893	20,820,886
Emission Reductions during the Monitoring Period (tCO_2-e)	27,185,554	8,691,936	35,877,491
Length of the Reporting period / Length of the Monitoring Period (# days/# days)	0.03	1.00	
Emission Reductions during the Reporting Period (tCO_2-e)	**923,058**[1]	**8,691,936**[2]	**9,614,995**[3]

[1] Oct 30th, 2020, to Dec 31st-2020.
[2] Jan 1st, 2021, to Dec 31st, 2021.
[3] Oct 30th, 2020, to Dec 31st, 2021.

Excel table with emission reduction full calculation can be viewed at following link.
All calculation including Monte Carlo and sensitivity analysis are available here.

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

5.1 Identification, assessment and addressing sources of uncertainty

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Activity Data						
Measurement	☑	☑	The identification of the 4000 points was carried out by visual interpretation of the satellite images. For each point and on each reference date (2000, 2005, 2010, 2015, 2020), a land cover class code was assigned according to the 11 classes defined in the nomenclature (to refer to SOP_2-response design). The photo-interpreter should especially indicate whether the nature of the point has changed over time if there has been a real land cover/land use changes at that location. Photointerpretation is a probabilistic science whose certainty of the choice of the land cover/use class can vary according to the difficulty of identifying this class. Indeed, a land cover class is characterized by its colour, size, shape, structure, texture, and its arrangement with neighboring objects. On a satellite image, an object class can appear under different colours and shapes and the same colour can belong to different land cover classes. The same class can be represented by several colours depending on the nature of the soil and the nature, structure, and composition of the vegetation cover. Moreover, in tropical and subtropical regions seasonality phenomena have a strong influence on the radiometry and spectral signature of biophysical objects, which sometimes can be confused and considered as a real change of land cover/land use between two dates. The difficulties to interpret these land cover classes can lead to confusions between the 11 land cover classes which are summarized in the confusion matrices provided in the FORM 3_Data	high	Yes	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			collection_RCI_V2. Interpretation difficulties may be more prevalent for some land cover classes. As seen from the confusion matrices provided in FORM 3_Data collection_RCI_V2. In the forest classes (class 11, 12, 13, 14), it is obviously the mixed heterogeneous classes where the confusions are the most important especially the transition forest class (class 12) and agroforestry (class 14). Agroforestry (class 14) is a complex system composed of an association of forest species forming a tree layer and shrubby / perennial crops (including palm trees) and/or rainfed crops. In Ivory coast a cocoa plot (class 21) with tree cover will be assigned to this class and the tree density should be comprised between 20% and 70%. Concerning the secondary forest (class 12), the tree crowns are no longer joined but are still important and are still made up of local natural tree species. The tree density should be comprised between 30% and 70% resulting from degradation of a natural forest or regeneration or a secondary status to a forest stage. Hence, the difference between these two classes (class 12 and class 14) concern the lower strata of shrub and grass and therefore whether this stratum is cultivated or not. The confusion of these two classes is understandable. In a few cases some confusion between class 12 transitional woodland and class 50 Grass, scrub and shrub land have been found. This class 50 refers to a mixed formations composed of grassy, shrubs and thickets stratum. The shrub layer may be more or less dense and associated with scattered trees and according to the density of trees, this class could be confused with class 12. Less fundamental to the ERP			

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			but quite frequent are the confusions between the cropping systems (class 21, 22, 23) and class 50 Grass, scrub and shrub land. Indeed, these shrubby formations may be the result of natural regeneration of agricultural land through rotation or shifting cultivation. According to the age of the fallow land (old or young fallow land) confusion between these two classes (class 12 and class 50) may be possible			
Representativeness	☑	☒	Sampling was carried out over the entire study area and all reference and monitoring periods. It can therefore be concluded that the impact of this source of uncertainty is low.	Low	Yes	No
Sampling	☒	☑	The sampling method is probabilistic based on a stratified approach with an optimal allocation of samples by strata according to Neyman's method on the basis of a first sub-sample to estimate the variance of each stratum in order to estimate the variance of each stratum in terms of characterization of changes. However, the changes are numerous, diffuse and individually cover relatively small areas in the study area. Therefore, they are difficult to characterize and despite the collection of large number of samples, some categories of change show high variance. The selection of the estimator follows the recommendations of Cochran (1977) and the GFOI MGD (2020).	High	Yes	Yes
Extrapolation	☑	☒	The estimates were made on the basis of the samples collected and for which the interpretation of the land cover classes are exhaustive and cover the whole reference and monitoring periods. This source of error is therefore unlikely to be present in the approach adopted.	Low	Yes	No

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Approach 3	☑	☒	This source of uncertainty exists when there is no land monitoring or Approach 3 of the IPCC monitoring, which is the case for Côte d'Ivoire. Indeed, Côte d'Ivoire uses country-specific and spatially explicit data whose estimation is described above in the measurement section of this table	Low	Yes	No
Emissions factors						
DBH measurement	☑	☑	In order to guarantee the quality of data, the following QA/QC procedures have been applied: • Design of a field data collection manual to serve as a guide ; • Training of data collection teams; • Conducting a pilot phase that allowed teams to understand the collection process; • Field data collection in 2 formats, paper (field sheet) and digital (tablets on which the Collect tool was installed); • Verification of the conformity of the data collected on the field sheets and tablets, allowing for corrections if necessary; • The creation of 2 mixed teams for on-site verification of 8% of the total sample units already inventoried. These teams were made up of SEP-REDD+, universities and research centers, and civil society organizations. • Data cleaning based on a cross-check between the 2 information sources (digital file and paper format) allowed for error correction.	*Low*	*YES*	*NO*
H measurement	☑	☑		*Low*	*YES*	*NO*
Plot delineation	☑	☑	Sampling units are clusters of 500 m x 500 m consisting of four rectangular observation plots of 25 m x 200 m. Each SU thus covers an area of 25	*Low*	*YES*	*NO*

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			hectares. The coordinates of the center of these units correspond to those of the points on the survey plan. The inventory teams were trained in delimiting and installing the sampling units. Tools such as GPS, compasses, and marking equipment were used for this purpose. All procedures are described in the inventory guide.			
Wood density estimation	☑	☑	The allometric equation for biomass prediction involves the specific wood density. A correspondence to obtain wood densities of these species has been established based on tree measurements. For each species, a correspondence is sought in the Global Wood Density Database and a mean wood density is associated with each tree, at the lowest level (species, genus or family). For all trees whose scientific names do not correspond or do not have known scientific names, a default value of the basic wood density of 0.58 g.m-3 which is the average value for tropical Africa (Reyes et al., 1992). This concerned exactly 14,376 listed trees.	*Low*	*YES*	*NO*
Biomass allometric model	☑	☑	In the absence of allometric equations specific to forest formations in Côte d'Ivoire, the use of Globallometry has been put to use. The estimation of above-ground biomass (AGB) was made using a pantropical allometric equation. Queries made in the Globallometree database showed that at least 73 allometric equations are specific to Côte d'Ivoire. Most of these equations are specific to forest plantations (Teak, Gmelina, Acacia, etc.) and/or certain timber and woodworking species (Mahogany, Niangon, etc.). However, these equations are not	*Low*	*YES*	*NO*

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
			suitable for national-scale application and all phytogeographic zones of the country. In order to represent all types of forests, the pantropical allometric equation (4) developed by Chave et al. (2014) was used to convert field measurements into estimates of above-ground biomass as it is estimated to be more robust and includes data from other pantropical equations including Brown's equation (1997), Chave's equation (2005) and Fayolle's equation (2013). This equation includes tree data from Africa. It is based on diameter at breast height (DBH), tree height, and wood basic density. This process is described in the biomass study report.			
Other parameters (e.g. Carbon Fraction, rootto-shoot ratios)	☑	☑	The QA/QC process applied to biomass from the literature consisted first of a comparison with results from other authors who worked under the same conditions and ecological zones. The idea here is to ensure that the results are substantially similar. Then a check of the calculations was carried out by redoing the calculations. The objective is to obtain the same values as the author using their data.	*Low*	*YES*	*NO*
Representativeness	☑	☒	Data used within ERP are at the Tier 2 level (country-specific data) and come from the national forest inventory of 2017 for forests (dense and secondary forest of the ombrophilic sector; dense and secondary forest of the mesophilic sector). There are a total of 150 sample units, each with 4 plots, for a total of 600 plots. The data are sufficiently representative of the program area and have allowed for precise estimates of emission factors. Details can be found in section 3.1 and via this link.	*Low*	*YES*	*NO*
Integration						

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Model	☑	☒	Control Mechanisms of material errors have been included in emission and removal calculation tools, i.e., sums of sampling points by forest type coincide with sample size ensuring no double counting in the sample-based activity data estimate. See the check of deforested areas in cells O29-R29 and the check of Forest Gain areas in cells Y223-AB223 in the Integration Tool. QA/QC procedure during ERs estimates includes ensuring all these cells show an "Ok" label before reporting ER estimates.	Low	*YES*	*NO*
Integration	☑	☒	Activity Data and Emission Factors are comparable. Carbon densities have been estimated according to the forest types, and non-forest land uses interpreted in the visual assessment.	Low	*YES*	*NO*

5.2 Uncertainty of the estimate of Emission Reductions

Parameters and assumptions used in the Monte Carlo method

Ivory Coast's ER Program applied Monte Carlo methods (IPCC Approach 2) for quantifying the Uncertainty of the Emission Reductions. Because the MC propagation analysis includes 146 parameter values, it has been provided access to uncertainty and emission factor calculation tool[13] to see all parameter values used in the analysis. The sources of uncertainty propagated in the Monte Carlo (MC) analysis are provided in the following Table.

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Deforestation and Degradation Emission Factors	The MC analysis included **13** Carbon density values for forest types and non-forest land uses categories considered in emission estimate. See all values in the Uncertainty calculation tool "Input_data&Models" Sheet – (cells F6..F19)	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Removal factors	The MC analysis included **4** Removal factors. See all values in the Uncertainty calculation tool "Input_data&Models" Sheet cells F22, F24, F26 and F28	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Deforestation Activity Data	**Forty-six** values for the Reference Period and **29** activity data for the Monitoring Periods were included in MC analysis. See all values in the Uncertainty calculation tool, "Input_data&Models" sheet, cells G32..G127 for Reference Period and cells G128..G223 for the Monitoring Periods.	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Activity Data for estimating inherited removals	The MC analysis included **32** Activity Data values for estimating inherited removals. See all values in the Uncertainty calculation tool "Input_data&Models" sheet, cells G228..G310.	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Permanent Forest's Degradation	**Fifteen** values for the Reference Period and **7** activity data for the Monitoring Periods were included in MC analysis. See all values in the Uncertainty calculation tool, "Input_data&Models" sheet, cells G314..G377 for Reference Period and	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).

[13] Uncertainty calculation tool can be accessed at the following link: https://1drv.ms/x/s!AmRJ_eqaQcEHhbggP4saEk9uPtvW8Q?e=tLK86e

	cells G378..G441 for the Monitoring Periods.			

Quantification of the uncertainty of the estimate of Emission Reductions

		Reporting Period		Crediting Period	
		Total Emission Reductions*	**Forest degradation ****	**Total Emission Reductions***	**Forest degradation****
A	**Median**	**8,823,626**	NA	**8,823,626**	NA
B	**Upper bound 90% CI** (Percentile 0.95)	**11,183,082**	NA	**11,183,082**	NA
C	**Lower bound 90% CI** (Percentile 0.05)	**6,628,335**	NA	**6,628,335**	NA
D	**Half Width Confidence Interval at 90% (B – C / 2)**	**2,277,373**	NA	**2,277,373**	NA
E	**Relative margin (D / A)**	**26%**	% NA	**26%**	% NA
F	**Uncertainty discount**	**4%**	% NA	**4%**	% NA

*Remove forest degradation from the estimate if forest degradation has been estimated with proxy data.
**Remove the column if forest degradation has not been estimated using proxy data.

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

The following table show each parameter's contribution to the Emissions Reduction's uncertainty. Three parameters represent 39% of total ER's uncertainty: i. Carbon Density of Dense Forest-ombrophile stratum (16.2%), ii. Removal Factor of Agro-foret-<20 yr (14.2%) and iii. Activity Data Deforestation 2020-2021 mesophile stratum Secondary Forest to Other crops conversion 8.5%).

	Corresponding Input Value				
Input Variable	Low Output	Base Case	High Output	Swing	Percent Swing^2
CD-11-Dense Forest-ombrophileDF	248.45	280.26	312.07	711,214	16.2%
RF-Agro-foret-<20 yr	-2.90	-11.59	-20.28	664,156	14.2%
AD-Defo_2020-2021_mesophile_SF-OC	5,448.11	2,060.20	(1,327.70)	514,170	8.5%
CD-50-Grassland-GG	84.23	39.88	-4.47	372,620	4.5%
AD-Defo_2020-2021_ombrophile_SF-OC	1,608.99	608.66	(391.67)	315,694	3.2%
AD-Defo_2000-2010_ombrophile_DF-CC	68,067.38	81,268.77	94,470.15	307,888	3.0%
CD-12-Secondary Forest-ombrophileSF	131.02	147.57	164.11	290,731	2.7%
CD-21-Cocoa-CC	50.27	45.40	40.53	267,480	2.3%
AD-Defo_2020-2021_ombrophile_SF-HH	1,608.99	608.66	(391.67)	256,478	2.1%
AD-Defo_2010-2015_ombrophile_DF-CC	20,834.15	28,788.64	36,743.12	180,239	1.0%
AD-Defo_2015-2020_ombrophile_DF-OC	12,441.20	6,385.04	328.88	168,196	0.9%
AD-Defo_2020-2021_mesophile_AF-OC	1,652.50	625.11	(402.28)	157,010	0.8%
AD-Defo_2000-2010_ombrophile_DF-OC	9,923.35	16,706.53	23,489.70	156,795	0.8%
AD-Defo_2020-2021_ombrophile_AF-OC	1,608.99	608.66	(391.67)	154,740	0.8%

CD-22-Perennial crops-PC	129.59	104.10	78.61	146,894	0.7%
AD-Defo_2010-2015_ombrophile_SF-CC	65,343.65	81,012.16	96,680.68	144,297	0.7%
AD-Defo_2015-2020_ombrophile_DF-GG	9,912.75	4,865.35	(182.05)	141,834	0.6%
AD-Defo_2015-2020_ombrophile_DF-CC	5,628.33	2,128.35	(1,371.64)	118,938	0.5%
AD-Defo_2015-2020_ombrophile_SF-CC	27,874.99	19,902.31	11,929.62	118,500	0.5%
CD-11-Dense Forest-mesophileDF	141.76	165.30	188.84	107,930	0.4%
AD-Defo_2015-2020_ombrophile_SF-OC	9,810.23	5,497.10	1,183.97	106,685	0.4%
AD-Defo_2015-2020_ombrophile_SF-GG	12,438.07	7,648.53	2,858.99	101,018	0.3%
AD-Defo_2020-2021_ombrophile_AF-HH	1,608.99	608.66	(391.67)	95,524	0.3%
CD-14-Agro-forest-AF	58.71	54.20	49.69	92,989	0.3%
AD-Defo_2020-2021_ombrophile_AF-CC	2,631.54	1,217.32	(196.91)	92,285	0.3%
CD-23-Other crops-OC	9.68	5.53	1.38	90,171	0.3%
AD-Defo_2015-2020_mesophile_SF-OC	8,520.22	4,560.64	601.06	88,431	0.3%
AD-ForestGain_2000-2010_mesophile_00_10-AF	3,873.45	1,753.20	(367.06)	87,988	0.2%
CD-60-Other lands-OL	84.23	39.88	-4.47	86,844	0.2%
AD-Defo_2020-2021_mesophile_AF-CC	1,652.50	625.11	(402.28)	86,419	0.2%
AD-Defo_2000-2010_ombrophile_SF-CC	45,580.78	58,148.89	70,717.00	86,004	0.2%
AD-Defo_2010-2015_ombrophile_DF-OC	3,799.87	8,039.35	12,278.83	85,694	0.2%
AD-Defo_2000-2010_ombrophile_SF-OC	18,384.32	27,333.00	36,281.68	84,417	0.2%
AD-Defo_2015-2020_mesophile_DF-CC	2,982.80	1,128.09	(726.62)	83,850	0.2%
AD-Defo_2015-2020_mesophile_SF-GG	9,638.46	4,745.52	(147.43)	82,744	0.2%
AD-Defo_2015-2020_ombrophile_AF-OC	9,323.79	5,171.64	1,019.49	82,663	0.2%
AD-Defo_2010-2015_mesophile_SF-PC	6,225.57	2,685.31	(854.94)	81,609	0.2%
AD-Defo_2000-2010_ombrophile_DF-GG	6,882.35	12,059.02	17,235.69	81,162	0.2%
AD-ForestGain_2000-2010_mesophile_00_10-SF	2,701.92	1,250.22	(201.48)	79,571	0.2%
AD-Defo_2015-2020_mesophile_SF-CC	10,389.91	6,631.94	2,873.97	78,768	0.2%
AD-Defo_2015-2020_mesophile_AF-OC	7,079.95	4,375.76	1,671.57	78,539	0.2%
AD-Defo_2015-2020_mesophile_DF-GG	1,652.50	625.11	(402.28)	78,378	0.2%
AD-Defo_2010-2015_ombrophile_AF-PC	1,608.99	608.66	(391.67)	77,547	0.2%
AD-Defo_2015-2020_ombrophile_AF-GG	10,619.45	5,474.01	328.56	75,150	0.2%
AD-Defo_2015-2020_mesophile_AF-CC	13,458.25	7,430.83	1,403.40	73,942	0.2%
AD-Defo_2015-2020_mesophile_SF-HH	1,652.50	625.11	(402.28)	73,338	0.2%
AD-Defo_2015-2020_ombrophile_AF-CC	8,558.95	5,236.99	1,915.03	72,549	0.2%
AD-Defo_2015-2020_mesophile_AF-GG	2,701.92	1,250.22	(201.48)	72,055	0.2%
AD-ForestGain_2000-2010_mesophile_Before 00-10-AF	132,870.22	113,286.57	93,702.93	70,838	0.2%
AD-ForestGain_2000-2010_mesophile_Before 00-10-SF	121,621.84	103,210.44	84,799.04	70,838	0.2%
AD-ForestGain_2010-2015_mesophile_Before 00-10-AF	122,340.51	103,344.21	84,347.91	70,838	0.2%

AD-ForestGain_2015-2020_mesophile_Before 00-10-AF	108,240.53	90,287.40	72,334.28	70,838	0.2%
AD-ForestGain_2020-2021_mesophile_Before 00-10-AF	107,591.55	89,662.29	71,733.04	70,838	0.2%
AD-ForestGain_2010-2015_mesophile_Before 00-10-SF	63,211.80	49,667.42	36,123.04	70,838	0.2%
AD-ForestGain_2015-2020_mesophile_Before 00-10-SF	50,880.67	38,352.71	25,824.76	70,838	0.2%
AD-ForestGain_2020-2021_mesophile_Before 00-10-SF	47,719.77	35,667.40	23,615.03	70,838	0.2%
AD-ForestGain_2010-2015_mesophile_10_15-AF	14,169.70	8,055.94	1,942.17	70,838	0.2%
AD-ForestGain_2010-2015_mesophile_10_15-SF	7,760.92	3,935.53	110.14	70,838	0.2%
CD-13-Forest plantations / reforestation-mesophilePP	417.43	241.44	65.45	70,838	0.2%
CD-13-Forest plantations / reforestation-ombrophilePP	417.43	241.44	65.45	70,838	0.2%

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

In Côte d'Ivoire, **the State is the owner of the ER titles**, as described in Article 1 of Decree 2021-674 dated 03 November 2021. A legal and regulatory framework has been put in place specifically for the transfer of ER titles resulting from the implementation of the ERP and is exclusive to the geographical scope and duration of the ERP. It is reflected in Decree 2021-674 of 03 November 2021. This decree can be viewed at the following link.
Which stipulates that a contractual volume of 10 million tonnes of carbon equivalent are exclusively transferred to the carbon fund for the FCPF in accordance with the provisions of the Tranche A and B ERPAs signed on 30 October 2020. This agreement can be viewed at the following link.
The terms and conditions for the management of ERs are specified in the interministerial decree 0183/ MEF/MEMINADER/MINEF/MBPE/MINEDD dated 16 February 2022. It can be viewed at the following link.
Subsequently, the carbon credits resulting from the additional volume of ERs under this programme are transferred to the FCPF's carbon fund after negotiation and approval by the parties of the ERPAs.
The government of Côte d'Ivoire, through the Ministry of Economy and Finance (MEF), is the only legal entity that holds and transfers ER titles to a third party.

6.2 Implementation and operation of Program and Projects Data Management System

The SEP REDD+ is in charge of supervising REDD+ projects at the national level. To fully play this role, it is necessary to ensure that the REDD+ activities that are implemented in the territory comply with the guidelines and commitments made in the National REDD+ Strategy. To meet this requirement, and in accordance with its mission according to its creation decree. It can be viewed at the following link.
The SEP-REDD+ key role is the following :

- Manages the national data management system for REDD+ programs and projects (precise geographic limits of the target area or geolocation to avoid possible overlap, description of planned activities, scope and carbon pools concerned, MRV data, applicable environmental and social safeguards, etc.);
- Communicates all ER information generated by REDD+ projects to the entity in charge of the ER transaction registry, in this case the MEF;
- Avoids multiple declarations of emission reductions or double counting. To this end, a web platform is under development. It will provide the public with information on the Programme, including details on the geographical boundaries of the Programme. The carbon pools and baseline, the amount of ERs that will be transferred to the Carbon Fund with associated reversal and uncertainty buffer accounts. This would ensure transparency of the process.

6.3 Implementation and operation of ER transaction registry

In order to be able to issue its own legal documents, Côte d'Ivoire needs a so-called transaction registry. That is, a registry that allows for the issuance, serialisation and management of legal titles evidencing ERs. This registry, which is required by international carbon standards, is more akin to the control and legitimacy that the project owner must exercise in the intervention area. It is different from the one[14] described in section 6.2 above. In the absence of such an instrument, Côte d'Ivoire has decided to rely on the FCPF-CF's transaction register (*Carbon Assets Trading System (CATS)*). However, as per article 3 of the inter-ministerial decree on ERs of 16 February 2022 0183/ MEF/MEMINADER/MINEF/MBPE/MINEDD, which specifies the legal provisions taken by the country for the development of its own National Carbon Credit Registry. Thus, the MEF is in charge of setting up and managing the future Carbon Credit Registry for the purpose of registering each carbon credit, individualising it by means of serialisation and converting it into a carbon certificate, as well as ensuring its monitoring.

[14] Geoportal website : www.geoportailsst.com

Currently, the development of this registry has not yet started. It is planned to build on the experiences of using the FCPF CATS registry during the implementation of the ERP for the development of own registry which can be used for future transactions with other partners.

6.4 ERs transferred to other entities or other schemes

The ERP is the first emission reduction programme in Côte d'Ivoire. Côte d'Ivoire has signed, in 2020, an ERPA for 10 million TeqCO2 that will be fully (100%) transferred to the FCPF and an additional call option for 6.5 million TeqCO2. The transfer has therefore not been made to date, neither to third parties nor to other programs. There is therefore no negative impact vis-à-vis the ERP. Only the transfer to the FCPF will be valid within the framework of the program.

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)

Intentionally left blank because the information is not available for the first period.

7.2 Quantification of Reversals during the Reporting Period

Intentionally left blank, since the information is not available for the first period.

Using the table below, please confirm and quantify any Reversals of ERs that have been previously transferred to the Carbon Fund, that might have occurred during the Reporting Period.

Refer to ***indicator 19.1*** *of the Methodological Framework and the FCPF ER Program Buffer Guidelines*

A.	**ER Program Reference level for this Reporting Period (tCO_2-e)**	*from section 4.1*		
B.	**ER Program Reference level for all previous Reporting Periods in the ERPA (tCO2-e).**	*from previous ER Monitoring Reports*		**+**
C.	**Cumulative Reference Level Emissions for all Reporting Periods [A + B]**			
D.	**Estimation of emissions by sources and removals by sinks for this Reporting Period (tCO_2-e)**	*from section 4.2*		
E.	**Estimation of emissions by sources and removals by sinks for all previous Reporting Periods in the ERPA (tCO_2-e)**	*from previous ER Monitoring Reports*		
F.	**Cumulative emissions by sources and removals by sinks including the current reporting period (as an aggregate accumulated since beginning of the ERPA) [D + E]**			**–**
G.	**Cumulative quantity of Total ERs estimated including the current reporting period (as an aggregate of ERs accumulated since beginning of the ERPA) [C – F]**			

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

7.3 Reversal risk assessment

The reversal risk assessment using the CF Buffer Guidelines has not changed since the preparation of the revised final ERPD.

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk		**10 %**		*10 %*
Lack of broad and sustained stakeholder support	Since the official launch of the ERP, numerous actions have been carried out to make the project known to stakeholders and beneficiaries. In addition, information missions have been organised in all the ERP regions so as to mobilise stakeholders around the project by informing them of the ERP's expectations and their contribution to the project's success. These missions also made it possible to provide stakeholders with the information they needed to understand the ERP, and to share information sheets for the mapping of ERP contributors/beneficiaries with a view to updating the database of ERP beneficiaries. For a better ownership of the ERP, the regional REDD+ committees led by the regional prefects (made up of the Prefectural Body, Regional Councils, local representatives of key technical ministries such as Environment, Water and Forests, Agriculture and development actors, NGOs and Associations,	**10 %**	*Medium risk -5%.*	*5 %*

	communities, etc.) are in charge of raising awareness of populations and monitoring activities at the local level. Thus, the 5 regional committees that make up the ERP area have been formed to fully play their role. The benefit-sharing plan was developed in a transparent and participatory manner with all the beneficiaries through consultation workshops. In addition, the signing of an agreement between each beneficiary and the Parks and Reserves Foundation allows the beneficiaries to know their responsibilities in the implementation of the project. Draft agreements have been prepared for the different types of beneficiaries. However, no agreements have been signed yet. They are planned to be signed in October 2023 following the update of the BSP and ahead of the first ER payments. On the issue of land-related conflicts, a national land security programme (PNSFR) has been set up to secure land rights and settle land conflicts in the area at the national level, including the ERP. Through the PNSFR, a Rural Land Policy Improvement and Implementation Project (PAMOFOR) was implemented where 37,000 rural land certificates will be issued in 2023. Description of the PAMOFOR project can be consulted via this link. In addition, a Feedback and Grievance Redress Mechanism (FGRM) has been developed and is operational in the project area.			
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	Since 2012, at the national level, the National REDD+ Commission has been created, which is an intersectoral organization for analysis, advice and guidance for the implementation of the REDD+ mechanism at the national level (see section 1.1). It is composed of a National REDD+ Committee (CN-REDD+) in charge of steering the REDD+ mechanism, a REDD+ Inter-ministerial Technical Committee (CTI REDD+) in charge of intersectoral coordination between the different key ministries, and a Permanent Executive Secretariat REDD+ (SEP-REDD+) in charge of the coordinated implementation of the REDD+ mechanism at the national level. The decree creating the national REDD+ commission can be consulted at this address. At the regional level, the country's organisation includes a range of government and local organisations and project implementers. To ensure regional supervision of the ERP. Awareness-raising, information, installation and training campaigns for Regional REDD Committees have been organised by SEP-REDD+ since 2012. The	**10 %**	*Medium risk* *-5 %*	*5 %*

	prefects and presidents of regional councils (as representatives of the 5 Regional REDD+ Committees concerned) are responsible for monitoring the various ERP activities at the local level. At the private sector level, the Cocoa and Forest Initiative (CFI) which since 2017 is a public-private platform committed to stop deforestation, reduce the impacts of climate change and land degradation, while improving the livelihoods of smallholder farmers. To this end, it enables collaboration at both national and regional levels, with Regional REDD+ Committees in each Region of the ERP area. Thus, the ERP has strong institutional capacity, whose initiatives in the area of combating deforestation are coordinated by a single body: SEP-REDD+ under the supervision of CN-REDD+, including cross-sectoral bodies (CN-REDD+, CFI, local REDD+ Committees), bringing together different relevant administrations, organisations, and the private sector of cocoa to ensure a better collaboration The risks associated with institutional capacity for implementation are medium: 5% reduction.			
Lack of long term effectiveness in addressing underlying drivers	ERP interventions are directly focused on two of the main drivers and agents of deforestation and degradation in the region (cocoa farming and unsustainable logging). The ERP incorporates a series of measures that maintain the production levels of the main commodities causing deforestation and degradation while streamlining their territorial space. The measures listed in section 1 and table 2 address these factors. In general, the actions can be summarised as follows: • The establishment of a legal and regulatory framework conducive to achieving long-term REDD+ objectives; • The effectiveness of economic decoupling due to deforestation and forest degradation; • The implementation of relevant incentive systems for the adoption of sustainable agricultural practices in the long term, including beyond the life of the project; • The promotion of non-carbon benefits to beneficiaries and stakeholders; • Promotion of sustainability programmes. The risk of reversal due to the lack of long-term effectiveness in addressing the underlying factors is considered medium: 2% reduction.	**5 %**	*Medium risk* *-2 %*	*3%*

Exposure and vulnerability to natural disturbances	The ERP sees no significant natural risks due to fire, drought, extreme weather events or other natural hazards regarding this study. The forest areas remain wet even during dry periods and therefore have a low fire risk. For fires, the FIP has strengthened SODEFOR's monitoring resources for classified forests and OIPR's for the Taï National Park and protected areas. The Special Surveillance and Intervention Unit of the Directorate of Water and Forests has also been set up and a squadron of aircraft has been created for surveillance, intervention and mapping. In addition, actions aimed at mitigating any risk linked to natural disturbances Various actions have also been carried out. • Development of the climate change adaptation system (global MRV system) which will be used to correlate mitigation efforts (reduction of deforestation) with MRV adaptation measures implemented at the multi-sectoral level ; • Promotion of smart agricultural practices; • Establishment of a fire and bushfire control programme at national level; • Existence of a pest management plan, available here. The risk is thus considered low: 5% reduction.	**5 %**	*Low risk -5 %*	*0 %*
		Total reversal risk set-aside percentage		*23 %*
		Total reversal risk set-aside percentage from ER-PD or previous monitoring report (whichever is more recent)		*23%*

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

A.	**Emission Reductions during the Reporting period (tCO_2-e)**	*from section 4.3*	**9,614,994.71**
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)**		**9,614,994.71**
D.	**Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested**	*from section 6.1*	100%
E.	**ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes**	*from section 6.4*	0
F.	**Total ERs (B+C)*D-E**		**9,614,994.71**
G.	**Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period**	*from section 5.2*	4%
H.	**Quantity of ERs to be allocated to the Uncertainty Buffer (0.15*B/A*F)+(G*C/A*F)**		384,599.79
I.	**Total reversal risk set-aside percentage applied to the ER program**	*from section 7.3*	23%
J.	**Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)**		1,661,471.09
K.	**Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*5%**		461,519.75
L.	**Number of FCPF ERs (F- H – J – K)**		**7,107,404.09**

ANNEX 4: CARBON ACCOUNTING - ADDENDUM TO THE ERPD

Technical corrections

The technical corrections made to the Reference Level are the following:

- **Reference Period**: The reference level for the ERP was initially incorrect due to a mistake in the calculation of the length of the reference period. It was initially determined to last 16 years (January 1, 2000 to December 31, 2015) which, is in line with the reference level submitted to the UNFCCC in 2017. However, according to criteria 11.2 and 16 of the Methodological Framework, the reference period should not exceed 15 years. To correct this issue, a pro-rata estimate of a 15-year Forest Reference Emission Level / Forest Reference Level was calculated. Considering that the reference period was estimated based on two monitoring events (2000-2010 and 2010-2015), the emission of the 2000-2010 period was pro-rated to an adjusted period 2001-2010. Finally, the new Reference Level was calculated by adding adjusted emissions of 2001-2010 with emissions of 2010-2015 to obtain the reference level emission adjusted to 15-year reference period. This correction is line with the technical correction number three "corrections of material errors, omissions and misstatements", as per the FCPF positive list of allowed technical corrections.
- **Recalculation of activity data.**
  These corrections result from the improvement of the methodological approach used. Initially, in the ERPD, activity data was determined based on the combination of several maps on which a random sampling system is applied to carry out visual interpretations through operators, as recommended by Olofsson et al. (2013 and 2014). Although this approach reduces the errors of omission of change, they remain significant. A hybrid approach for estimating areas has been adopted to correct these errors and obtain relevant and precise results; it incorporates the following features:
  - "Large" sample size: the sample size is dense enough (46415 sample points over the ER-Program area) to capture changes;
  - Spatially balanced sampling between the different strata: the points of the different classes have the same weight;
  - Interpretation to assign occupancy classes and changes: use of several change detection algorithms from several sources of satellite images and other spatially explicit information and visual interpretation;
  - Principle of cross-validation, both for machine interpretation (convergence of evidence) and human interpretation (elimination of subjective bias);
  - Quality control and integrated quality assurance at all stages of the process.

  This approach made it possible to obtain more robust activity data for the reference period and monitoring period. The document with the methodology details is available at this link. This correction is in conformity with the technical correction number two, as per the FCPF positive list of allowed technical corrections.

- **Update of emission and removal factors.** Emission and absorption factors were updated. This correction complies with the technical correction number one, as per the FCPF positive list of allowed technical corrections. The updates are summarized below:

  Forest carbon densities: Dense Forest and secondary forest biomass values have been updated considering the recommendations of Carbon Fund participants in 2019 relating to the plot stratification approach. Indeed, the initial approach developed in the ERPD indicated a classification of the sampling units of the forest inventory based on the rate of cover estimated from the visual interpretation of satellite images, deemed irrelevant. Data updating is based on direct field observations that inventory teams provide during surveys. Field sheets[15] and database[16] describing the land cover category of the sampling units are available. Biomass values related to agroforests and forest plantations under the ER Program were obtained through

[15] NFI Field sheets: https://drive.google.com/drive/folders/1FZjLxTm6qc5RakJ0x2GoOuQNqVbaTNLg?usp=share_link
[16] NFI land cover category database - http://reddplus.ci/download/forest-type-biomass/

the literature. These are the results from work carried out by Asigbaase et al., (2021)[17] in Ghana. Indeed, before the submission of the ERPD in January 2019, no legal texts were ruling on the agroforest category as a forest class. Since the clarification provided by the forest code LAW N ° 2019-675 OF JULY 23, 2019, available here, this correction has been considered by integrating emission factors from the agroforest category.

Non-Forest carbon densities: Initially, it was assumed that Cocoa biomass is carbon density for non-forest land use. Other non-forest land use was included in the carbon accounting due to the re-calculation of activity data. Therefore, the following carbon densities were included in the calculation of emissions from deforestation: perennial crops, annual crops, and grassland (see table 1). The biomass values for these land uses were obtained through the literature.

Removal factors: in the ER-PD the removals estimate is based on native forest regeneration only (see table 2). Forest plantation and Agro-forest removals were included. For forest plantations and agroforestry systems IPCC (2006) values of tables 5.2 and 4.10 were used. BGB annual growth was excluded.

Table 1: Carbon densities update.

Land use	Num	Sector	Deforestation emission factor	AGB+BGB tCO2/ha	
				ERPD	Annex 4
Forest	1	Ombrophile	Dense forest	426.5	483.0
	2		Secondary forest	298.7	254.3
	3	Mesophile	Dense forest	246.6	284.9
	4		Secondary forest	180.5	140.4
	5	Forest Plantations / reforestation < 20 yrs		Not considered	241.4
	6	Forest Plantations / reforestation >20 yrs		Not considered	529.7
	7	Agro-forest		Not considered	54.2
Non-Forest	8	Cocoa		54.7	45.4
	9	Perennial crops		Not considered	104.1
	10	Other crops (Annual crops)		Not considered	5.53
	11	Grasslands		Not considered	39.88

Table 2: Removal factors update.

Land Use category	AGB tdm/ha/yr	
	ERPD	Annex 4
Agro-foret (Tropical Wet Africa, Shaded Perennial)	Not considered	3.16
Forest Plantations / reforestation; Tropical moist deciduous forest Other Spp	Not considered	4.23
Secondary Forest Mesophile	2.35	2.35
Secondary Forest Ombrophile	3.29	3.29

[17] Asigbaase, Michael; Dawoe, Evans; Lomax, Barry H.; Sjogersten, Sofie (2021). Biomass and carbon stocks of organic and conventional cocoa agroforests, Ghana. Agriculture, Ecosystems & Environment, 306(), 107192–. doi:10.1016/j.agee.2020.107192 https://sci-

- **Update of forest degradation estimate:** Initially, the forest degradation emissions estimate corresponded to the area of forest land remaining in the Forest Land category with a decrease in cover and biomass in the ombrophile and mesophilic areas. It had been considered as forest degradation in those forest areas with a forest cover rate of more than 70% in 2000, which decreased to a forest cover rate between 30-70% in 2015. Now, this calculation corresponds to the areas of forested lands converted into other forest types. All transitions between secondary and dense forests, agroforests, and forest plantations are considered. This correction is in line with technical correction number 2b iii, as per the FCPF positive list of allowed technical corrections.

- **Update of removals estimate:** Carbon removals estimate include all secondary forest cohorts regenerated after 2000. The Secondary Forest regenerated before the reference period is assumed as Degraded Forests. Land converted to forest land CO_2 removals have been estimated following the recommendations set in the Guidance Note for accounting of legacy emissions/removals of the FCPF (version 1). A conservative default period of 20 years is assumed for the forest to grow from the carbon stock levels of non-forest to the level of biomass in the average forest. The removal estimate considers changes in carbon stocks in aboveground biomass. The changes in the total carbon stocks in biomass (removals) during the reference period were determined as the sum of the total carbon stocks in biomass of all land units. This correction is in line with technical correction number 1, as per the FCPF positive list of allowed technical corrections.

Start Date of the Crediting Period

In accordance with the signed ERPA, the start date of the crediting period is October 30, 2020.
This date corresponds to the definition of the start date of the crediting period provided in the FCPF Glossary, i.e. follows:
- It is no earlier than 2019, the date of inclusion of the program in the portfolio of the carbon fund.
- It does not fall under the reference period 2000-2015.

7. CARBON POOLS, SOURCES AND SINKS

7.1 Description of Sources and Sinks selected

Sources/Sinks	Included?	Justification/Explanation
Emissions from deforestation	*Yes*	Emissions from deforestation that correspond to the conversion of forest land (FL) to other lands (OL) are considered in the calculation of the reference level and also for monitoring, reporting, and verification (MRV). The data necessary for their quantification are available at the program area level. Initially, the data used to estimate deforestation came from the study on the drivers of deforestation in Côte d'Ivoire (wall to wall mapping). These data were updated in 2022 using an approach based on the hybrid interpretation (man/machine) of dense systematic sampling (1km/1km grid), providing a better result.
Emissions from forest degradation	Yes	In accordance with Criterion 3 and Indicator 3.3, emissions from degradation have been included in the baseline for the program area. Indeed, the estimation of forest degradation carried out previously in the ERPD was based solely on the visual interpretation of samples generated on forest land according to the level of tree cover. Forest degradation activity data was updated in 2022 using an approach based on the hybrid interpretation (man/machine) of dense systematic sampling (1km/1km grid). This approach improved the quality of the results. Forest degradation calculation corresponds to the areas of forested lands converted into other forest types. All transitions between secondary and dense forests, agroforests, and forest plantations are considered.
Enhancement of carbon stock	Yes	Activity data from carbon stock enhancement activities (conversion of other land to forest land) were considered. These are mainly removals related to reforestation, natural regeneration, and agroforestry plantations. These data are obtained from field surveys (polygons) coupled with interpretations of satellite images.
Conservation of carbon stocks	No	These source/sink have not been considered in the national FREL due to absence of a clear national definition of this activity.

7.2 Description of carbon pools and greenhouse gases selected

Carbon Pools	Selected?	Justification/Explanation
Above Ground Biomass (AGB)	Yes	Above-ground biomass has been considered in the ER-Program FREL emissions/removals calculations for deforestation, forest degradation, and carbon stock enhancement activities. The country has data collected at the national level (IFN), which were used to estimate GHG emissions relating to above-ground biomass and to calculate the national FREL. We also have data from the literature for cocoa, reforestation, agroforests, and perennial and annual crops (ER-MR section 3.1).
Below Ground Biomass (BGB)	Yes	Belowground biomass was considered in the calculation of GHG emissions/removals of the FREL of the ER-Program for activities related to deforestation, forest degradation and enhancement of carbon stock. It was estimated based on aboveground biomass using the root-stem ratio (Tx) according to ecological zone (see ER-MR section 3.1 on BGB).

Dead Wood	No	This carbon pool was not considered for the calculation of the GHG emissions of the NERF of the ERP. There is not deadwood data for all land uses considered in the carbon accounting.
Litter	No	This carbon pool was not considered for the calculation of the GHG emissions of the NERF of the ERP. There is not litter data for all land uses considered in the carbon accounting.
Soil Organic Carbon (SOC)	No	Soil organic carbon is not considered in the emissions/removal's calculations. This pool is excluded from the calculations in accordance with indicator 4.2 of the methodological framework which specifies that the exclusion of the soil carbon pool is considered a conservative measure, as it underestimates the emission reductions.

GHG	Selected?	Justification/Explanation
CO_2	Yes	Carbon dioxide (CO_2) from deforestation, forest degradation and increased carbon stocks is the only gas considered for the construction of the FREL
CH_4	No	CH_4 is not considered in the reference level. In accordance with indicator 4.2 of the methodological framework, the exclusion of CH_4 is considered a conservative measure, as it underestimates the emission reductions during the program period.
N_2O	No	N_2O is not considered in the reference level. In accordance with Indicator 4.2 of the Methodological Framework, the exclusion of N_2O is considered a conservative measure, as it underestimates emission reductions over the program period.

8 REFERENCE LEVEL

8.1 Reference Period

The reference period is Jan 1, 2001- December 31, 2015, i.e., 15 years. This extension of 10 years as the reference period recommended by the FCPF methodological framework is justified by the availability of good quality satellite data to estimate changes in forest areas at the scale of the program.

8.2 Forest definition used in the construction of the Reference Level

The definition of the forest used for the construction of the FREL complies with that definition submitted by Côte d'Ivoire to the UNFCCC, which refers to the Ivorian Forest Code of July 2019, available here. According to the Ivorian Forest Code, Forest means "any land constituting a dynamic and heterogeneous environment, excluding plant formations resulting from agricultural activities, with a minimum area of 0.1 hectare bearing trees whose crown covers at least 30% of the surface and which can reach at maturity a minimum height of 5 meters.

8.3 Average annual historical emissions over the Reference Period

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

Reference Level ($\mathbf{RL_{RP}}$)

Net emissions of the RL from deforestation over the Reference Period (RL_{RP}) are estimated as the sum of annual change in total biomass carbon stocks (deforestation and degradation), and annual removals (ΔC_{B_t}) during the reference period.

$$\boldsymbol{RL_{RP}} = \frac{\sum_t^{RP} \Delta \boldsymbol{C_{LU_{RP,i,t}}}}{\boldsymbol{RP}} \qquad \textbf{\textit{Equation 13}}$$

Where:

$\Delta C_{LU_{RP,i,t}}$	=	Balance of emissions during the Reference Period in the Accounting Area of the ER Program that corresponds to the sum of annual change in carbon stocks and removals for each of i REDD+ activities at year t; tCO_2*$year^{-1}$.
RP	=	Reference period; years.

Annual change in total biomass carbon stocks forest land converted to another land-use category ($\Delta C_{B_{defo,t}}$)

Emissions from deforestation were estimated based on the Deforestation Sheet of Activity data tool[18] following the 2006 IPCC Guidelines, the annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta C_{B_{defo,t}}$) would be estimated through the following equation:

$$\Delta C_{B_{defo,t}} = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L \qquad \textbf{\textit{Equation 14}} \text{ (Equation 2.15, 2006 IPCC GL)}$$

Where:

$\Delta C_{B_{defo,t}}$	Annual change in carbon stocks in biomass on land converted to other land-use category, in tones C yr^{-1};
ΔC_G	Annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tones C yr^{-1};
$\Delta C_{CONVERSION}$	Initial change in carbon stocks in biomass on land converted to other land-use category, in tones C yr^{-1}; and

[18] Activity data tool link : https://1drv.ms/x/s!AmRJ_eqaQcEHhbhPWf9sMBwmN9xzOg?e=3dB7mU

ΔC_L Annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tones C yr^{-1}.

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document[19] for applying IPCC Guidelines and guidance in the context of REDD+, the above equation will be simplified and it will be assumed that: a) the annual change in carbon stocks in biomass ($\Delta \boldsymbol{C_B}$) is equal to the initial change in carbon stocks ($\Delta \boldsymbol{C_{CONVERSION}}$); b) it is assumed that the biomass stocks immediately after conversion is the biomass stocks of the resulting land-use. Therefore, the annual change in carbon stocks would be estimated as follows:

$$\Delta \boldsymbol{C_B} = \Delta \boldsymbol{C_{CONVERSION}}$$

$$\Delta C_{B_t} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) \text{ x CF x} \frac{44}{12} \times A(j,i)_{RP}$$

Equation 15 (Equation 2.16, 2006 IPCC GL)

Where:

$A(j,i)_{RP}$ Area converted/transited from forest type j to non-forest type *i* during the Reference Period, in hectares per year. In this case, twenty-four forest land conversions are possible:

1 Agro-forest to Cocoa
2 Agro-forest to Grassland
3 Agro-forest to Human settlement
4 Agro-forest to Other crops
5 Agro-forest to Other lands
6 Agro-forest to Perennial crops
7 Dense Forest to Cocoa
8 Dense Forest to Grassland
9 Dense Forest to Human settlement
10 Dense Forest to Other crops
11 Dense Forest to Other lands
12 Dense Forest to Perennial crops
13 Forest plantations / reforestation to Cocoa
14 Forest plantations / reforestation to Grassland
15 Forest plantations / reforestation to Human settlement
16 Forest plantations / reforestation to Other crops
17 Forest plantations / reforestation to Other lands
18 Forest plantations / reforestation to Perennial crops
19 Secondary Forest to Cocoa
20 Secondary Forest to Grassland
21 Secondary Forest to Human settlement
22 Secondary Forest to Other crops
23 Secondary Forest to Other lands
24 Secondary Forest to Perennial crops

Technical corrections: Initially, the data used to estimate deforestation came from the study on the drivers of deforestation in Côte d'Ivoire (wall to wall mapping). These data were updated in 2022 using an approach based on the

[19]Page 44, GFOI (2013) Integrating remote-sensing and ground-based observations to estimate emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.

hybrid interpretation (man/machine) of dense systematic sampling (1km/1km grid), providing a better result.

$B_{Before,j}$	Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground ($AGB_{Before,j}$) and belowground biomass ($BGB_{Before,j}$) and it is defined for each forest type.
$B_{After,i}$	Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest IPCC Land Use categories. **Technical corrections**: Dense Forest and secondary forest biomass values have been updated considering the recommendations of Carbon Fund participants in 2019 relating to the plot stratification approach. Data updating is based on direct field observations that inventory teams provide during surveys. Field sheets[20] and database[21] describing the land cover category of the sampling units are available. Biomass values related to agroforests and forest plantations under the ER Program were obtained through the literature. The following carbon densities were included in the calculation of emissions from deforestation: perennial crops, annual crops, and grassland. The biomass values for these land uses were obtained through the literature.
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.
44/12	Conversion of C to CO_2

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{deg,t}}$)

Following the 2006 IPCC Guidelines the annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{DEG}}$) could be estimated through the Gain-Loss Method or the Stock-Difference Method as described in Chapter 2.3.1.1 of Volume 4 of the 2006 IPCC Guidelines.

$$\Delta C_B = \Delta C_G - \Delta C_L$$ **Equation 16** (Equation 2.7, 2006 IPCC GL)

$$\Delta C_B = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$ **Equation 17** (Equation 2.8 (a), 2006 IPCC GL)

ΔC_B	Annual change in carbon stocks in biomass for each land sub-category, in tones C yr^{-1}
ΔC_G	annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, tones C yr-
ΔC_L	annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, tones C yr-1
C_{t_2}	total carbon in biomass for each land sub-category at time t_2, tonnes C
C_{t_1}	total carbon in biomass for each land sub-category at time t_1, tonnes C

Following the recommendations set in chapter 2.2.2 of the GFOI Methods Guidance Document[22] for applying IPCC Guidelines and guidance in the context of REDD+, the above equation will be simplified, and it will be assumed that: a) the annual change in carbon stocks in biomass (ΔC_B) due to degradation is equal to the annual decrease in

[20] NFI Field sheets: https://drive.google.com/drive/folders/1FZjLxTm6qc5RakJ0x2GoOuQNqVbaTNLg?usp=share_link
[21] NFI land cover category database - http://reddplus.ci/download/forest-type-biomass/

[22] Page 48, GFOI (2013) Integrating remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.

carbon stocks (b) the decrease in carbon stocks occurs the year of conversion. The long-term decrease in carbon stocks indicated in equation (1) of the GFOI MGD is assumed here to be zero. Therefore, considering the GFOI MGD the IPCC equation for forest degradation could be expressed as an Emission Factor time activity data as follows:

$$\Delta C_{B_{DEG}} = \sum_{j} \{EF_j \times A(a,b)_{RP}\} \qquad \textbf{Equation 18}$$

Where:

EF_j Emission factor for degradation of forest type a to forest type b, tones CO2 ha^{-1}.

$A(a,b)_{RP}$ Area of forest type a converted to forest type b (transition denoted by a,b) during the Reference Period, ha yr^{-1}.

Technical corrections: Initially, the forest degradation emissions estimate corresponded to the area of forest land remaining in the Forest Land category with a decrease in cover and biomass in the oenophiles and mesophilic areas. It had been considered as forest degradation in those forest areas with a forest cover rate of more than 70% in 2000, which decreased to a forest cover rate between 30-70% in 2015. Now, this calculation corresponds to the areas of forested lands converted into other forest types. All transitions between secondary and dense forests, agroforests, and forest plantations are considered.

Annual change in carbon stocks in biomass on non-forestland converted in forestland ($\Delta C_{B_{reg}}$)

Land converted to forest land CO2 removals has been estimated following the recommendations set in the Guidance Note for accounting of legacy emissions/removals of the FCPF (version 1). Since the FCPF Methodological Framework requires IPCC Tier 2 or higher method, the net annual CO2 removals are calculated using equations 2.15 and 2.16 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. These equations were simplified by assuming that the conversion from non-forest to forest occurs during a period from average carbon stocks in non-forest to average carbon stocks in forests. A conservative default period of 20 years is assumed for the forest to grow from the carbon stock levels of non-forest to the level of biomass in the average forest. The removal estimate considers changes in carbon stocks in aboveground biomass. Using the outcome of equation 2.15 and 2.16, it was determined the changes in the total carbon stocks in biomass (removals) during the reference period as the sum of the total carbon stocks in biomass of all land units. From the point of view of notations, the emission factors in equation EQ7 above would be replaced by $\mathbf{RF}_{SREG}$ in enhancement of carbon stocks in new forests.

$$\Delta C_{B_{reg}} = \sum_{LU=1}^{n} \{RF_{reg} \times A(i,j)_{RP}\} \qquad \textbf{Equation 19}$$

Where:

RF_{reg} enhancement of carbon stocks in new forests [tCO2*ha*$year^{-1}$].

$A(j,i)_{RP}$ Area of non-forestland *i* converted to forestland *j* (transition denoted by *i,j*) in the Reference Period, ha yr^{-1}.

LU Land unit.

Technical corrections: Carbon removals estimate include all secondary forest cohorts regenerated after 2000. The Secondary Forest regenerated before the reference period is assumed as Degraded Forests. Land converted to forest land CO_2 removals have been estimated following the recommendations set in the Guidance Note for accounting of legacy emissions/removals of the FCPF (version 1). A conservative default period of 20 years is assumed for the forest to grow from the carbon stock levels of non-forest to the level of biomass in the average forest. The removal estimate considers changes in carbon stocks in aboveground biomass. The changes in the total carbon stocks in biomass (removals) during the reference period were determined as the sum of the total carbon stocks in biomass of all land units

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

Activity data

Parameter:	$A(j,i)$
Description:	*Area converted from forest type j to non-forest type i during the reference period (2000-2015).*
Data unit:	*Hectare per year.*
Value monitored during this Monitoring / Reporting Period:	*Ombrophile zone* *Table 1: Annual deforestation and degradation (ha/ year) in the ombrophile zone between 2000-2015*

Deforestation	*From Dense Forest (DF) to Cocoa Crops (CC)*	*7337,16*
	From Dense Forest (DF) to Perennial Crops (PC)	*40,58*
	From Dense Forest (DF) to Other Crops (OC)	*1649,72*
	From Dense Forest (DF) to Grassland (GG)	*1258,74*
	From Dense Forest (DF) to Human Settlement (HH)	*40,58*
	From Secondary Forest (SF) to Cocoa Crops (CC)	*9277,40*
	From Secondary Forest (SF) to Perennial Crops (PC)	*1324,00*
	From Secondary Forest (SF) to Other Crops (OC)	*2663,89*
	From Secondary Forest (SF) to Grassland (GG)	*1428,39*
	From Secondary Forest (SF) to Human Settlement (HH)	*62,27*
	From Secondary Forest (SF) to Other Lands (OL)	*0,00*
Degradation	*From Dense Forest (DF) to Secondary Forest (SF)*	*5490.94*
	From Dense Forest (DF) to Forest Plantation (PP)	*0,00*
	From Dense Forest (DF) to Agroforest (AF)	*449,17*
	From Secondary Forest (SF) to Agroforest (AF)	*1627,94*
	From Secondary Forest (SF) to Dense Forest (DF)	*141,89*

Mesophile zone

Table 2: Annual deforestation and degradation (ha/ year)in the mesophile zone between 2000-2015

Deforestation	*From Dense Forest (DF) to Cocoa Crops (CC)*	*2090,77*
	From Dense Forest (DF) to Perennial Crops (PC)	*0,00*
	From Dense Forest (DF) to Other Crops (OC)	*275,43*

	From Dense Forest (DF) to Grassland (GG)	*350,64*
	From Dense Forest (DF) to Human Settlement (HH)	*00,00*
	From Dense Forest (DF) to Other Lands (OL)	*41,67*
	From Secondary Forest (SF) to Cocoa Crops (CC)	*3891,34*
	From Secondary Forest (SF) to Perennial Crops (PC)	*179,02*
	From Secondary Forest (SF) to Other Crops (OC)	*1605,26*
	From Secondary Forest (SF) to Grassland (GG)	*1109,14*
	From Secondary Forest (SF) to Human Settlement (HH)	*41,67*
	From Secondary Forest (SF) to Other Lands (OL)	*137,35*
Degradation	*From Dense Forest (DF) to Secondary Forest (SF)*	*1084,71*
	From Dense Forest (DF) to Forest Plantation (PP)	*0,00*
	From Dense Forest (DF) to Agroforest (AF)	*350,64*
	From Secondary Forest (SF) to Agroforest (AF)	*649,76*

Table 3: Forest gain (ha) between 2000-2010 and 2010-2015

	2000-2010	*2010-2015*	
Ombrophile zone			
Secondary forest (SF)	*2128*	*3369*	
Agroforest (AF)	*-*	*9126*	
Mesophile zone			
Secondary forest (SF)	*1250*	*3936*	
Agroforestry (AF)	*1753*	*8056*	

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

The activity data used for the reference period was obtained from a sampling approach for estimating areas that incorporates the following characteristics:
A sufficiently dense and balanced sample size to capture changes in land cover classes.
Hybrid machine (algorithm) / human (visual) interpretation to assign land cover classes and changes: Several change detection algorithms, from several sources of satellite images and/or other spatially explicit information and visual interpretation were used to detect change classes.
Cross-validation principle, both for machine interpretation (convergence of evidence) and human interpretation (elimination of subjective bias). This required the formalization of decision rules.
Quality control and integrated quality assurance at all stages of the process.
5. The FAO technical team in charge of forest monitoring has developed tools to facilitate the design and implementation of this approach. All these tools and resources are available via this link:

The figure below shows the different stages of the process:

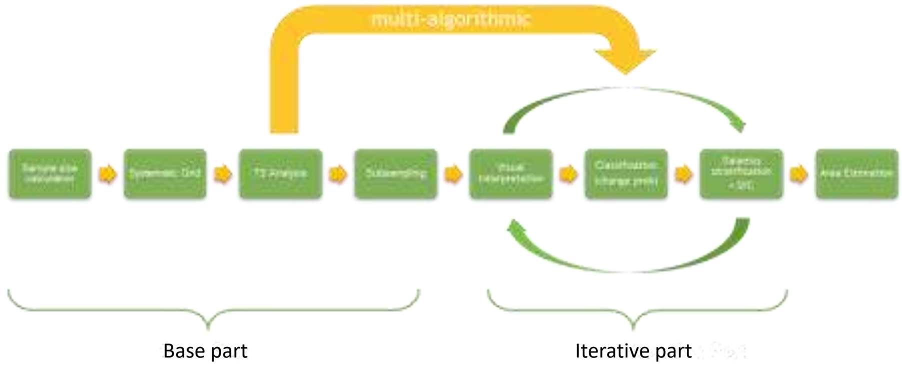


Figure 3: Steps in the methodological process for estimating activity data

Sampling design

An empirical analysis with a reference product (ESA CCI map 2015-2020) shows that a systematic sampling of 1km x 1km over the ERP area is required to capture the changes with a relative sampling error of less than 15% on the land cover change classes.
On this basis a rectangular systematic grid of 46,415 points was generated as illustrated in the figure below. The tool **erp_01_sbae_design** was developed to generate the samples.

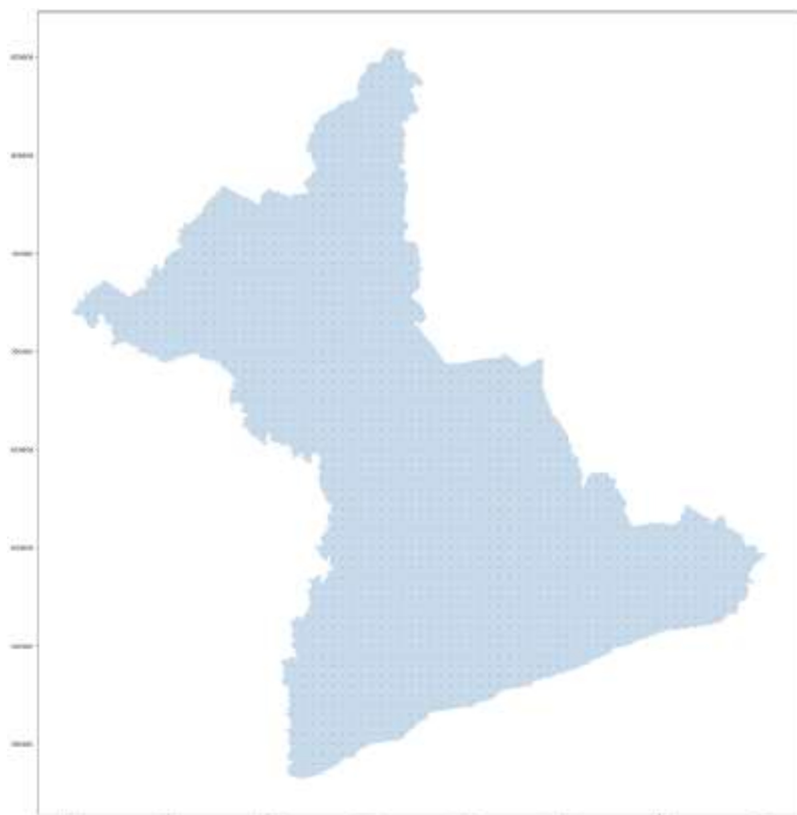


Figure 4: 1 sqkm grid adapted in the ERP

This established sampling system is stable over time and can be re-used for the regular updating of land cover change statistics.

Extraction of data (variables) from the assembly approach

Information from several global layers (TMF, GFC, ESA, DW, ESRI) is extracted for each of the points, as well as the normalized vegetation indices, from the entire Landsat archive. These index series are also analyzed with several algorithms (BFAST, CUSUM, CCDC, LandTrendR, and standard statistical descriptors). The list of variables used for this set approach is shown in the following table. These operations were performed using the notebook erp_02_extract_ts.

Name	Variables	Description	Reference	Link
Grid information	LON', 'LAT', 'PLOTID'	Coordinates and unique identifier of each point	Grid information	https://github.com/sepal-contrib/sbae_point_analysis
SRTM DEM	aspect', 'elevation', 'slope'	Digital elevation model variables	Farr et *al.* 2007	https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2005RG000183
Dynamic World	dw_class_mode', 'dw_tree_prob__max', 'dw_tree_prob__min', 'dw_tree_prob__stdDev', 'dw_tree_prob_mean'	Dominant Dynamic World land cover class and tree probabilities	Brown et *al.*, 2022	https://www.nature.com/articles/s41597-022-01307-4
ESA LC 2020	esa_lc20'	Global land cover product at 10 m resolution for 2020 based on Sentinel-1 and 2 data	Zanaga et *al.* 2021	https://worldcover2020.esa.int/
ESRI LC 2020	esri_lc20'	Sentinel-2 10m land cover time series of the world from 2017-2021	Karra, et *al.* 2021	https://www.arcgis.com/home/item.html?id=d3da5dd386d140cf93fc9ecbf8da5e31
GFC	gfc_gain', 'gfc_loss', 'gfc_lossyear', 'gfc_tc00'	Global Forest Change variables	Hansen et al. 2013	https://earthenginepartners.appspot.com/science-2013-global-forest
Canopy height model	lang_tree_height'	Tree height	Lang et al., 2022	https://arxiv.org/abs/2204.08322
Forest canopy height	potapov_tree_height'	Tree height	Potapov et al., 2020	https://www.sciencedirect.com/science/article/pii/S0034425720305381

TMF	tmf_20xx' .. 'tmf_20yy', 'tmf_defyear', 'tmf_degyear', 'tmf_main', 'tmf_sub'	Tropical Moist Forest variables, including yearly land cover	Vancutsem et al., 2021	https://www.science.org/doi/10.1126/sciadv.abe1603
Landsat Time series	dates', 'ts', 'images', 'mon_images'	Dates, spectral values and total number of USGS Landsat 4 to 9 acquisitions, Level 2, Collection 2, Tier 1	USGS, 2008	https://www.usgs.gov/landsat-missions/landsat-collection-2-level-1-data
CCDC	ccdc_change_date', 'ccdc_magnitude'	Continuous change detection and classification of land cover using all available Landsat data	Zhu and Woodock, 2014	https://www.sciencedirect.com/science/article/pii/S0034425714000248
LandTrendR	ltr_magnitude', 'ltr_dur', 'ltr_yod', 'ltr_rate', 'ltr_end_year'	Temporal segmentation for forest disturbance and recovery	Kennedy et al., 2010	https://www.sciencedirect.com/science/article/pii/S0034425710002245
BFAST	bfast_change_date', 'bfast_magnitude', 'bfast_means'	Near real-time disturbance detection using satellite image time series	Verbesselt et al., 2013	https://www.sciencedirect.com/science/article/pii/S0034425712001150?via%3Dihub
CUSUM	cusum_change_date', 'cusum_confidence', 'cusum_magnitude'	Cumulative Sum Test to Detect Land-Cover Changes	Kellndorfer, etal. 2019	https://gis1.servirglobal.net/TrainingMaterials/SAR/Ch3-Content.pdf
TS metrics	ts_mean', 'ts_sd', 'ts_min', 'ts_max'	Basic statistical metrics describing the time series	Vollrath, unpublished	https://github.com/sepal-contrib/sbae_point_analysis
Bootstrap	bs_slope_mean', 'bs_slope_sd', 'bs_slope_max', 'bs_slope_min'	Basic statistical metrics describing the trend of the time series	Vollrath, unpublished	https://github.com/sepal-contrib/sbae_point_analysis

Using the tool erp_02_extract_ts.made it possible to associate the information above with each sample.

Unsupervised aggregation of points

The information is injected into a cluster model that identifies points with similar trajectories for the different products. The clusters have different sizes, and correspond to homogeneous groupings of points, a priori distinguishing between change points and stable points. The goal is to make an unsupervised classification of the information on the points, to have different a priori batches of points with different trajectories of change. This allows points to be selected from all clusters to have a representative training dataset to be interpreted.

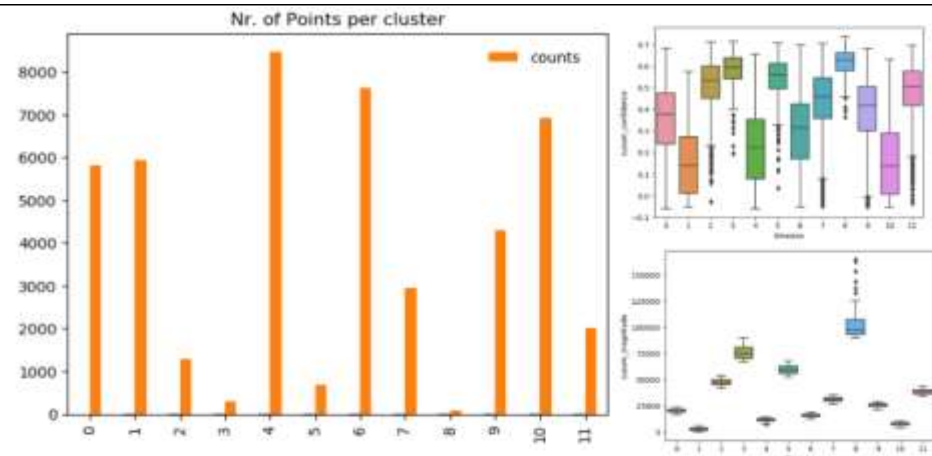


Figure 5 : Unsupervised cluster analysis (12 clusters 30 pts max / cluster 339 points)

The next step is to draw a small number of points (here ~30) in each of the clusters (339 in total) to produce a training dataset with descriptive variables of land use status and trends.
https://app.collect.earth/collection?projectId=32912
A project has been generated to collect this information by visual interpretation.

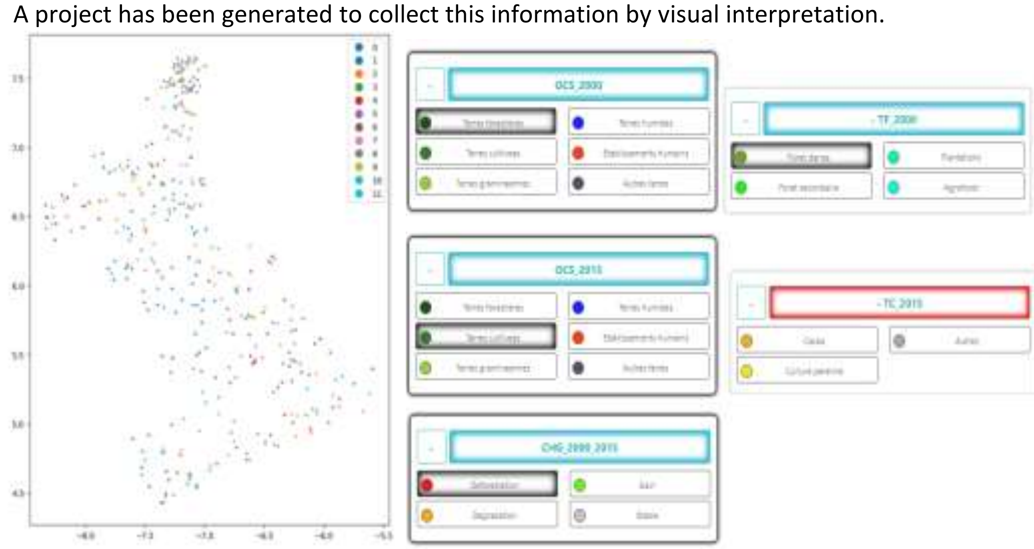


Figure 6: First interpreted dataset and survey form.

The collection of this reduced set of points is also an opportunity to check the robustness of the interpretation keys.

Supervised classification 1

CLUSTER	0	1	2	3	4	5	6	7	8	9	10	11
Deforestation	8	5	10	11	14	8	1	16	3	10	13	12
Degradation	1	0	1	1	0	0	2	0	0	1	0	0
Stable	21	25	19	18	16	22	27	14	6	19	17	18
Prop. Defor.	27%	17%	33%	37%	47%	27%	3%	53%	33%	33%	43%	40%
Total	7298	4572	1874	7617	1865	129	6187	8657	9	2953	5800	454

```
Maximum probability of stable for change points
0.8421333333333332
Reasonable probability of stable for change points
0.4304000000000006
Number of points above thshld (considered stable)
235 out of 339
Number of actual change points left in stable
11
```

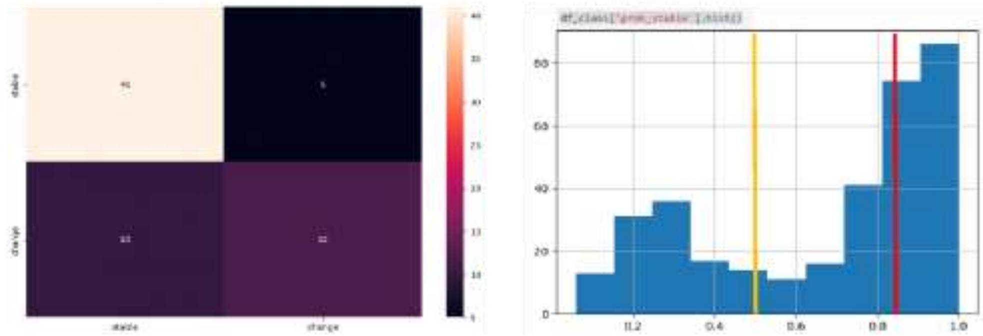


Figure 7 : Distribution of probabilities of being stable in the interpreted data set (339 points)

The data is then used to perform a supervised classification of the set of points with respect to land use change types.

Figure 7 illustrates the results of the supervised classification with two classes (deforestation and stable), through the distribution of the probabilities of being stable, for each of the 339 points. The red bar indicates the probability threshold (0.84) beyond which no change points were recorded and the yellow bar indicates the 90% percentile (probability of 0.49). The 339 sample points were considered statistically insufficient to represent the entire sample.

To address this shortcoming a second training dataset with a number of points was determined based on the approach described by Hidiroglou, M.A. and Kozak, M. (2018) and Dalenius, T. and Hodges Jr, J.L.(1957). It increases the precision of estimates by assigning different sampling fractions to strata. For this dataset, we have 692 samples (Figure 8).

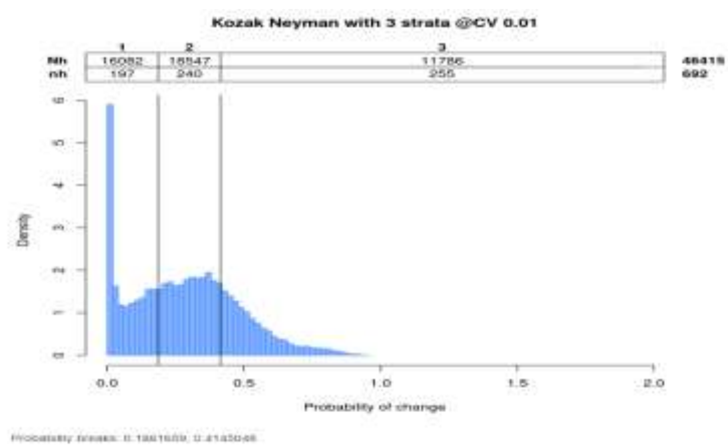


Figure 8: Change probability de changement according to Kozak Neyman

Supervised classification 2

The dataset of 692 points was interpreted according to the selection in the previous figure in order to serve as training for supervised classification using the *Random Forest* algorithm. This classification gives a good distribution and confirms the good representativeness of the 692 points in relation to the whole.

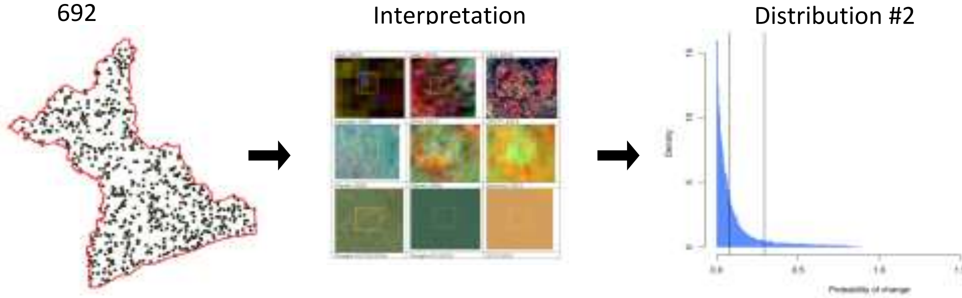


Figure 9: Supervised classification to achieve better class separation.

Final selection

Using the actual observed variance of the 692 points already interpreted, the combined Dalenius - Neyman method with 3 strata could be applied to arrive at the final selection of 3308 points, i.e. a total of 4000 points (with 692 points already interpreted) as illustrated in Figure 10. below.

These points were then interpreted in order to obtain the different classes of change in the ERP area over the period 2000 to 2021, thus covering the reference period (2000-2015) and the monitoring period (2020-2021).

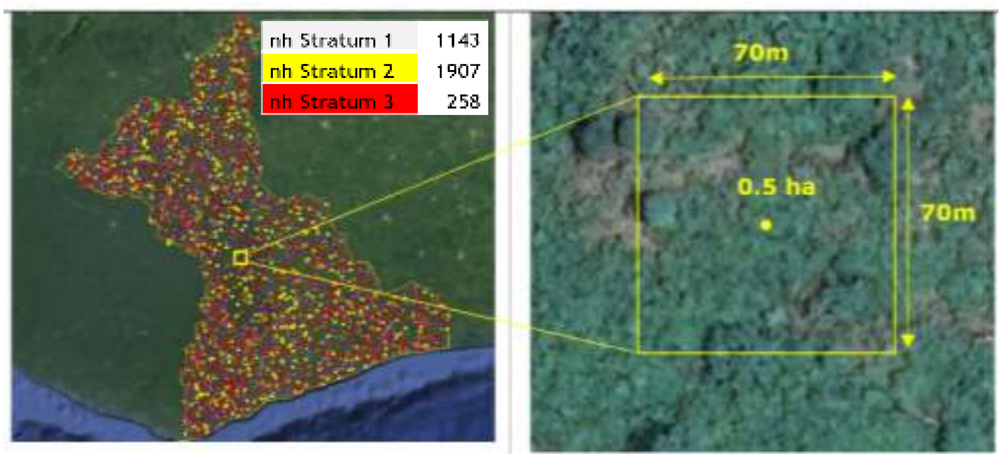


Figure 10 : Final Sample and exemple of a sample point

Sample Interpretation

The interpretation rules mentioned above were then presented and implemented during a workshop held in Paris, France from December 12 to 16, 2022 with the presence of IGN FI, World Bank and SEP REDD+ teams. This workshop helped harmonize the interpretations and reduce the margins of uncertainty. Following this workshop, all 4,000 selected points were interpreted. An analysis of the disagreements between interpretations was made possible by the double interpretation of the 692 points.

Following the analysis of the disagreements on the 692 points, it was necessary to perform a more thorough quality control in order to reduce the potential errors of interpretation as much as possible. Therefore, the points on which at least one change had been detected during the

	period 2000-2015 and 2020-2021 were reinterpreted representing 995 samples out of a total of 4,000. **Statistical analysis** All 4,000 samples, including those that were reinterpreted, were used as the basis for calculating area estimates and their uncertainty. The estimation of activity data was done using the stratified random estimator based on the formulas described by Cochran (1977) and GFOI (2020). Estimates are made for each of the land use categories considered (11 classes) and in terms of changes from one period to another representing a total of more than 60 effective combinations. Estimates and associated uncertainties are produced for each combination and for each phytogeographic zone (Mesophilic, Umbrophilic and Sub-Sudanian) considering the stratification applied. A detailed description of the calculation methods is available in the SOP_4_Data analysis_RCI.docx document.
QA/QC procedures applied:	The QA/QC procedures applied consisted of: First, standard operating procedures (SOPs) were developed as described in section 2.1 Interpretation was done by highly qualified professionals from the Ingénierie Géographique Numérique Française à l'International (IGN-FI based in France) who are specialized in the interpretation of land cover with satellite imagery. Also, a cross-interpretation of the first series of sample points (692) was carried out by expert photo-interpreters from IGN-FI who had not taken part in the first interpretation and the MRV experts from SEP REDD+. This step made it possible to assess the accuracy and bias of the photointerpretation to ensure better calibration. Following the analysis of the disagreements of the cross-interpretation, it appeared necessary to reinterpret a little less than 1000 samples in order to minimize the potential interpretation errors. The statistics associated with the different land use changes to determine the Activity Data were carried out by IGN-FI. The accuracy of the calculations and formulas used were independently verified by the FAO using an experienced statistician.
Uncertainty for this parameter:	*Quantification of uncertainties over the reference period (2000-2015)*

	Mesophile			**Ombrophile**		
Land cover change categories	**Estimation average (ha/an)**	**Confidence Interval 90% (ha)**	**Confidence Interval %**	**Estimation average (ha/an)**	**Confidence Interval 90% (ha)**	**Confidence Interval %**
Deforestation						
Agroforest (AF) to cocoa crops (CC)	621,15	461,34	73,76%	876,38	607,07	69,05%
Agroforest (AF) to Grassland (GG)	83,35	136,99	164,35%	81,15	133,38	164,35%
Agroforest (AF) to Other Crops (OC)	333,39	271,06	87,57%	263,62	336,96	127,39%

Agroforest (AF) to Human Settlement (HH)				81,15	94,28	116,18%
Dense Forest (DF) to Cocoa Crops (CC)	2090,77	792,79	45,20%	7337,16	1410,39	20,04%
Dense Forest (DF) to Perennial Crops (PC)				40,58	66,69	164,35%
Dense Forest (DF) to Other Crops (OC)	275,43	267,57	111,56%	1649,72	734,84	44,65%
Dense Forest (DF) to Grassland (GG)	350,64	364,21	69,25%	1258,74	611,60	48,15%
Dense Forest (DF) to Human Settlement (HH)				40,58	66,69	164,35%
Dense Forest (DF) to Other Land (OL)	41,67	68,49	164,35%			
Secondary Forest (SF) to Cocoa Crops (CC)	3891,34	1192,55	30,46%	9277,40	1882,44	20,86%
Secondary Forest (SF) to Perennial Crops (PC)	179,02	236,02	131,84%	1324,00	715,35	52,42%
Secondary Forest (SF) to Other Crops (OC)	1605,26	802,83	47,41%	2663,89	937,93	35,34%
Secondary Forest (SF) to Grassland (GG)	1109,14	649,22	61,56%	1428,39	713,18	49,05%
Secondary Forest (SF) to Human Settlement (HH)	41,67	68,49	164,35%	62,27	102,38	164,40%
Secondary Forest (SF) to Other Land (OL)	137,35	225,86	164,45%			
Degradation						
Dense Forest (DF) to Agroforest (AF)	350,64	319,54	94,26%	449,17	336,07	74,82%
Dense Forest (DF) to Secondary Forest (SF)	1084,71	675,55	72,34%	5490,94	1340,28	28,69%
Secondary Forest (SF) to Agroforest (AF)	649,76	536,57	81,51%	1627,94	887,69	58,69%

Gain			
2000-2010			
	Area (ha)	**Confidence Interval 90% (ha)**	**Confidence Interval (%)**
Ombrophile zone			
Secondary forest (SF)	*2128,35*	*3499.99*	*164.45*
Mesophile zone			
Secondary forest (SF)	*1250,22*	*1451.70*	*116,12%*
Agroforest (AF)	*1753.20*	*2120.26*	*120.94*

2010-2015

		Area (ha)	**Confidence Interval 90% (ha)**	**Confidence Interval (%)**
	Ombrophile zone			
	Secondary forest (SF)	*3 368,75*	*2 520,55*	*74,82%*
	Agroforest (AF)	*9 125,96*	*5 696,04*	*62,42%*
	Mesophile zone			
	Secondary forest (SF)	*3 935,53*	*3 825,39*	*97,20%*
	Agroforest (AF)	*8 055,94*	*6 113,77*	*75,89%*
Any comment:				

Value monitored during this Monitoring / Reporting Period:	*Ombrophile Zone*		
	onverted from forest type j to non-forest type i during the monitoring period (2020-		*Mesophile zone*
	re per year		
		From Agroforest (AF) to Cocoa Crops (CC)	1217.32
		From Agroforest (AF) to Cocoa Crops (CC) / *From Agroforest (AF) to Other Crops (OC)*	625,11 / 608.66
	Deforestation	*From Agroforest (AF) to Other Crops (OC)* / *From Agroforest (AF) to Human Settlement (HH)*	625,11
	Deforestation	*From Secondary Forest (SF) to Other Crops (OC)*	608.66
		From Secondary Forest (SF) to Human Settlement (HH)	608.66 / 2060,20
	Degradation	*From Secondary Forest (SF) to Agroforest (AF)* / *From Secondary Forest (SF) to Other Crops (OC)*	608.66 / 2060,20
	Gain	*Agroforest (AF)*	2060,20
	Degradation	*From Dense Forest (DF) to Secondary Forest (SF)*	*2128.35*
	Gain	*Agroforest (AF)*	*3085.55*
Source of data and description of measurement/calculation methods and procedures applied:	*See description for the reference period*		
QA/QC procedures applied:	*See description for the reference period*		

Uncertainty for this parameter:

Quantification of uncertainties over the reference period (2020-2021)

	Mesophile			Ombrophile		
Land cover change categories	**Estimation average (ha/an)**	**Confidence Interval 90% (ha)**	**Confidence Interval %**	**Estimation average (ha/an)**	**Confidence Interval 90% (ha)**	**Confidence Interval %**
Deforestation						
Agroforest (AF) to cocoa crops (CC)	625,11	1 027	164,4 %	1 217,32	1 414	116,2 %
Agroforest (AF) to Other Crops (OC)	625,11	1 027	164,4 %	608,66	1 000	164,3 %
Agroforest (AF) to Human Settlement (HH)				608,66	1 000	164,3 %
Secondary Forest (SF) to Other Crops (OC)	2 060,20	3 388	164,4 %	608,66	1 000	164,3 %
Secondary Forest (SF) to Human Settlement (HH)				608,66	1 000	164,3 %
Degradation						
Secondary Forest (SF) to Agroforest (AF)	2 060,20	3 388	164,4 %			
Dense Forest (DF) to Secondary Forest (SF)				2 128,35	3 500	164,4 %
Gain						
Agroforest (AF)	2 060,20	3 388	164,4 %	3 085,55	2 589	83,9 %

Any comment:

Emission factors

<table>
<tr><td>Parameter:</td><td>$AGB_{Before,j}$</td></tr>
<tr><td>Description:</td><td>Aboveground biomass of forest before conversion,</td></tr>
<tr><td>Data unit:</td><td>ton of dry matter per ha</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>
The data used in this document are from Tier 2 level (country-specific data) and come from the National Forest Inventory
) of 2017 for forests (dense forest and secondary forest in the ombrophilic sector; dense forest and secondary forest in the mesophilic sector). All NFI data and script can be found here.
Each teaching unit has 4 plots, for a total of 600 plots. The data are sufficiently representative of the program area and allowed accurate estimates of emission factors.
The biomass of forest strata before conversion was obtained using a 3-phase approach: (i) sampling plan development, (ii) field data collection and (iii) biomass estimation.

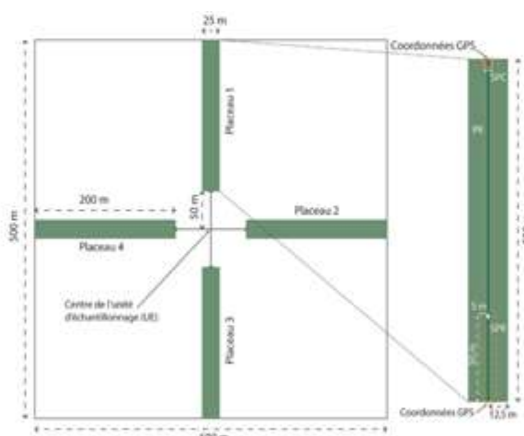
iv. Sampling plan
The sampling plan adopted for collecting forest biomass data in Côte d'Ivoire is stratified random and was based on the country's phytogeographical zoning (ombrophilous, Mesophilic, pre-forest and Sudanese).
This sampling technique has several advantages, including (i) the elimination of any subjectivity in the choice of sampling units to be measured, (ii) the calculation of parameters per stratum and of the distinct sampling error for certain strata, and (iii) the reduction of the variability of a parameter of a given stratum. Sampling units are available via this link.
are clusters of 500 m x 500 m consisting of four rectangular observation plots of 25 m x 200 m. Each SU thus covers an area of 25 hectares. The coordinates of the centre of these units correspond to the coordinates of the points on the survey plan. Once the centre of the SU is located and established, the four plots are set up inside the SU and arranged in a cross pattern. They are each located 50 m from the centre of the SU and are numbered clockwise from 1 to 4.


figure 2: Sampling unit
The forest strata resulting from the inventory are recorded in the table below:
</td></tr>
</table>

IPCC Category	Phytogeographic zones	Forest class
Forest land	Ombrophilous	Dense forest
		Secondary forest
	Mesophilic	Dense forest
		Secondary forest

v. **Data gathering**

A three-level collection system is implemented within each SU, corresponding to three different levels of readings:

- level 1 consists of four rectangular plots of 25 m x 200 m each intended for measuring trees with a DBH ≥ 10 cm, standing, dead wood standing, dead wood lying on the main strip (axis of the plot);
- Level 2 consists of a rectangular sub-plot of 10 mx 50 m each located inside each rectangular space. It is intended for measuring trees with small diameters (5 cm ≤ DBH < 10 cm);
- Level 3 consists of a square sub-plot of 5 m x 5 m in each plot and intended for the assessment of biodiversity (count of individuals of woody species with DBH < 5 cm and height ≥ 1.30 m).

For levels 1 and 2, the measurements related to the height, the diameter at breast height (DBH = 1.30 m) and observations on the health status of the tree. The diameter of lying dead wood was measured on the 200 m of the main section of the plot (level 1). For level 3, observations focused on the presence or absence of woody species whose total height is greater than or equal to 1.30 m and diameter less than 5 cm.

The details of the collection method can be viewed from the following link.

vi. **Estimation of above-ground biomass (AGB) at the sample level**

The pantropical allometric equation developed by Chave et al. (2014) was used to convert field measurements into estimates of aboveground biomass (AGB) because it is considered more robust (s= 0.357; Akaike Information Criterion (AIC)=3130 and df=4002), recent and covers a wide range of vegetation types, for a total of 4004 trees ranging in trunk diameter from 5 cm to 212 cm, and includes data from other pantropical equations including Brown's equation (1997), the Chave (2005) and that of Fayolle (2013).

Model 4 of the Chave et al. (2014) was used for biomass estimates. It is based on the diameter at breast height (DBH), the height of the tree and the basic density of the wood. The mathematical expression of this allometric equation is:

AGB = 0.0673 x (r DHP2 H)0.976

Where :

- AGB is the estimated aboveground biomass in Kg;
- D is the diameter at breast height in cm;
- H is the total height of the tree (m);
- r is the specific density of the wood (g.cm-3)

Value applied:	The Aboveground Biomass for the forest land category from the NFI are recorded in the following table <table><tr><th rowspan="2">Phytogeographic zone</th><th rowspan="2">Forest land category</th><th>AGB</th></tr><tr><th>tdm/ha</th></tr><tr><td rowspan="2">Mesophilic</td><td>Dense forest</td><td>134.70</td></tr><tr><td>Secondary forest</td><td>67.88</td></tr><tr><td rowspan="2">Ombrophilous</td><td>Dense forest</td><td>204.57</td></tr><tr><td>Secondary forest</td><td>107.71</td></tr></table> The Aboveground Biomass Spreadsheet can be viewed via this link
QA/QC procedures applied	To ensure data quality, the following QA/QC procedures were applied: • Design of a field data collection manual to serve as a guide. The manual can be viewed from the following link; • Training of collection teams; • Collection of field data in 2 formats, paper (field sheet) and digital (tablets on which the Collect tool of the Open Foris platform has been installed; • Verification of the conformity of the data collected in the field sheets and tablets; • Constitution of 2 mixed teams for the verification on the ground of 8% of the total of the formed sampling units. These teams were made up of SEP-REDD+, universities and research centres and civil society organizations. This control consisted in carrying out measurements on 8% of all the SUs in order to make comparisons with the measurements collected by the collection teams. In each SU, a plot is randomly selected and information such as plot dimensions, type of occupation and land use, DBH and height and species names were recorded. This information made it possible to correct some gaps. • **Clearance and aggregation** The information contained on the sheets and in the tablets was checked after the field phase to ensure their compliance and consistency. The field sheets have been digitized and archived. These files can be consulted here. Then, a cross between the 2 information sources made it possible to correct the names of the species, the input errors, the omissions and the commissions in the recording of the data. These operations resulted in a final database, which was used for the calculations of emission factors.

Uncertainty associated with this parameter:	Uncertainties in above-ground biomass (AGB) estimates for dense and secondary forests

	Above ground biomass (AGB)			
	Dense forest		Secondary forest	
Parameter	Ombrophilous	Mesophilic	Ombrophilous	Mesophilic
Standard error [tdm/ha]	17.44	12.91	9.11	5.60
Absolute error [tdm/ha]	29.83	22.74	15.52	9.62
Relative error [%]	14.58	16.88	14.41	14.17

Any comment:	

Parameter:	BGB $_{Before,j}$
Description:	Belowground biomass of category forest j before conversion
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Belowground biomass is calculated by applying the stem to root ratio on AGB for tropical forest as reported in Table 4.4 IPCC 2006 vol 4 (IPCC, 2006).
Value applied:	

Forest land category	**BGB**
	tdm/ha
dense mesophilic forest	30.60
Mesophilic secondary forest	13.58
Dense Rainforest	75.69
Secondary rain forest	39.85

The spreadsheet can be viewed here.
All resources (spreadsheets, script and input data) are available here.

<table>
<tr><td>QA/QC procedures applied</td><td>Refer to the QA/QC process of AGB before j</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>Uncertainties in belowground biomass estimates for dense and secondary forests
<table>
<tr><th></th><th colspan="4">Below-ground biomass (BGB)</th></tr>
<tr><td></td><td colspan="2">Dense forest</td><td colspan="2">Secondary forest</td></tr>
<tr><td>Parameter</td><td>Ombrophilous</td><td>Mesophilic</td><td>Ombrophilous</td><td>Mesophilic</td></tr>
<tr><td>Standard error [tdm/ha]</td><td>6.45</td><td>3.46</td><td>3.37</td><td>1.12</td></tr>
<tr><td>Absolute error [tdm/ha]</td><td>11.04</td><td>6.09</td><td>5.74</td><td>1.92</td></tr>
<tr><td>Relative error [%]</td><td>14.58</td><td>19.92</td><td>14.41</td><td>14.17</td></tr>
</table></td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>AGB After,i</td></tr>
<tr><td>Description:</td><td>Aboveground biomass of the cropland category: cocoa
In Côte d'Ivoire, the main driver of deforestation is agriculture, with cocoa production being the lead driver. Forests are largely converted to cocoa plantations, especially in the ER-Program area.</td></tr>
<tr><td>Data unit:</td><td>Ton of dry matter per hectare</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>The biomass for cocoa plantations comes from the study by N'Gbala et al., (2017).
Following an inventory carried out in cocoa plantations in the central western zone of the country, they used the diameter measurements at 30 cm from the ground (because cocoa trees generally branch off below 1.30 m) in the allometric equation de Segura et al., (2005), to determine the above-ground biomass of cocoa plantations. The article can be viewed via this link.</td></tr>
<tr><td>Value applied:</td><td>
<table>
<tr><th colspan="2">AGB</th></tr>
<tr><td rowspan="2">Cocoa</td><td>tdm/ha</td></tr>
<tr><td>37.2</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>QA/QC procedures applied</td><td>The above-ground biomass of cocoa plantations considered in this work (37.2 tdm/ha) is taken from the study by N'Gbala et al., (2017) see. the full study can be viewed here. https://doi.org/10.1016/j.agee.2017.01.015
This value more or less coincides with that of the study conducted by Nimo et al, (2021) in Ghana. Fully publication can be viewed by the following link. In their study, they estimated the aboveground biomass of cocoa plantations at 32.02 tdm/ha using the same methodological approach. This difference of about 5 tdm/ha between these two studies could be explained by the difference in age of the inventoried plantations, 26 years and 20 years respectively for N'gbala et al, (2017) and Nimo et al, (2021). Thus, with the addition of local context considerations, the value retained (37.2 tdm/ha) is considered relevant as a value of (above-ground) biomass for cocoa plantations in the ERP area.</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td><table><tr><th colspan="2">AGB</th></tr><tr><td>SE (standard error)</td><td>2.9</td></tr><tr><td>90% CI [tdm/ha]</td><td>4.77</td></tr><tr><td>90% CI [%]</td><td>13.34</td></tr></table></td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>$BGB_{After,i}$</td></tr>
<tr><td>Description:</td><td>Category Belowground Biomass: Cocoa</td></tr>
<tr><td>Data unit:</td><td>Ton of dry matter per hectare</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>The underground biomass for cocoa plantations comes from the study by N'Gbala et al. (2017). This study applied the allometric model r2 = 0.84 developed by Cairns et al., (1997) and widely used by a number of authors (Somarriba et al., 2013). This model is an accepted methodology within the framework of the IPCC on land use, land use change and forestry (Penman et al., 2003).</td></tr>
<tr><td>Value applied:</td><td><table><tr><th colspan="2">BGB</th></tr><tr><td rowspan="2">Cocoa</td><td>tdm/ha</td></tr><tr><td>8.2</td></tr></table></td></tr>
<tr><td>QA/QC procedures applied</td><td>This data from the literature has been re-evaluated by the MRV team in Côte d’Ivoire, which confirms that the values are consistent with those of the program area.</td></tr>
</table>

<table>
<tr><td>Uncertainty associated with this parameter:</td><td>

BGB	
SE (standard error)	0.6
90% CI [tdm/ha]	0.99
90% CI [%]	12.52%

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

<table>
<tr><td>Parameter:</td><td>$AGB_{After,i}$</td></tr>
<tr><td>Description:</td><td>Aboveground biomass of the category: Perennial crop
The category of land of the perennial crop type essentially includes agricultural commodities other than cocoa that are practiced in the ER-Program area. These are particularly rubber and palm oil;

Category	Subclass
Perennial crop	rubber tree
	Oil palm tree

</td></tr>
<tr><td>Data unit:</td><td>Ton of dry matter per hectare</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>The biomass for the perennial crop category is derived from the average biomass of rubber and oil palm plantations. The data for each of them are taken from the literature. These are regional studies carried out in Ghana.
Grieco et al., (2012) used information from an inventory in samples of rubber and oil palm plots. They used the sampling protocol used to detect changes in the aboveground biomass carbon pool proposed by the FAO: Assessing carbon stocks and modelling win-win scenarios of carbon sequestration through land-use changes. (Ponce Hernandez, 2004). The average age of plantations considered in this study of 10 years and 20 years respectively for rubber and oil palm.
The study by Grieco et al., (2012) can be consulted from the link and complete Ponce Hernandez, (2004) study from this link.</td></tr>
<tr><td>Value applied:</td><td>

AGB	
Perennial crop	**tdm/ha**
	86.7

</td></tr>
<tr><td>QA/QC procedures applied</td><td>According to Grieco et al. (2012) each of the crops (rubber and oil palm) have their above-ground biomass estimated in the study: 113.4 tdm for rubber and 60 tdm for oil palm. The relevance of using the average of these values including the applied value has been verified and confirmed by the MRV team in Côte d'Ivoire.</td></tr>
</table>

Uncertainty associated with this parameter:	<table><tr><td colspan="2">AGB</td></tr><tr><td>SE (standard error)</td><td>15.20</td></tr><tr><td>90% CI [tdm/ha]</td><td>25</td></tr><tr><td>90% CI [%]</td><td>28.84</td></tr></table>
Any comment:	

Parameter:	$BGB_{After,i}$
Description:	Belowground biomass of the category: Perennial crop The category of land of the perennial crop type essentially includes agricultural commodities other than cocoa that are practiced in the ER-Program area. These are particularly rubber and palm oil; <table><tr><td>Category</td><td>Subclass</td></tr><tr><td rowspan="2">Perennial crop</td><td>rubber tree</td></tr><tr><td>Oil palm tree</td></tr></table>
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Belowground biomass was calculated by applying the AGB stem-to-root ratio (Cairns et al., 1997; Mokany et al., 2006) considering that the underground biomass represents 20% of the aboveground biomass. All this information can be found in Grieco et al., (2012). Mokany et al (2006) complete study can be viewed by the following link.
Value applied:	<table><tr><td colspan="2">**BGB**</td></tr><tr><td rowspan="2">**Perennial crop**</td><td>**tdm/ha**</td></tr><tr><td>17.4</td></tr></table>
QA/QC procedures applied	According to Grieco et al. (2012) each of the crops (rubber and oil palm) had its underground biomass estimated in the study: 22.8 tdm for rubber and 12 tdm for oil palm. The relevance of using the average of these values including the applied value has been verified and confirmed by the MRV team in Côte d'Ivoire.
Uncertainty associated with this parameter:	<table><tr><td colspan="2">**BGB**</td></tr><tr><td>SE (standard error)</td><td>3.02</td></tr><tr><td>90% CI [tdm/ha]</td><td>4.97</td></tr><tr><td>90% CI [%]</td><td>28.58</td></tr></table>

Any comment:	

Parameter:	$AGB_{After,i}$
Description:	Aboveground biomass of category: Grassland In the ERP area, the grassland category consists mainly of shrublands as described in the land use class nomenclature available here.
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The data of the biomass for the grass category is taken from a regional study (Ilboudo, 2018) conducted in Burkina Faso (located north of Côte d'Ivoire). The author used inventory data (diameter at breast height and height measurements) in sample units to estimate the above-ground biomass of the grassland category using polynomial allometric equations (Mbow, 2009).
Value applied:	<table><tr><th colspan="2">AGB</th></tr><tr><td rowspan="2">grassland</td><td>tdm/ha</td></tr><tr><td>35.33</td></tr></table>
QA/QC procedures applied	The QA/QC procedure consisted of evaluating the differences between the applied value from Ilboudo (2018) and what has been done elsewhere by other authors. Thus, Amougou et al. (2016) obtained values close to Ilboudo (2018) in their study conducted on the carbon stock estimate in two land units in the savannah zone of Cameroon, available at this link. The results obtained were 15.47 tdm/ha and 32.58 tdm/ha. These values, slightly different from those of Ilboudo (2018), can be explained by the use of different allometric equations and the specificity of the different plant species. The values of these two studies being noticeably close, that of Ilboudo was retained because of the similar regional context with Côte d'Ivoire.
Uncertainty associated with this parameter:	<table><tr><th colspan="2">AGB</th></tr><tr><td>SE (standard error)</td><td>44.09</td></tr><tr><td>90% CI [tdm/ha]</td><td>72.53</td></tr><tr><td>90% CI [%]</td><td>205.29</td></tr></table>
Any comment:	

Parameter:	BGB After,i
Description:	Belowground Biomass Category: Grassland
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Belowground biomass was calculated by applying the AGB stem-to-root ratio (Cairns et al., 1997). According to Cairns et al., 1997 study, belowground biomass can be calculated from aboveground biomass using a global model that they developed for forest root biomass estimation from total aboveground biomass. The study found that below-ground biomass accounts for about 26% of the total biomass. Complete study is available at this address.
Value applied:	see table below
QA/QC procedures applied	See AGB grass land
Uncertainty associated with this parameter:	see table below
Any comment:	

Value applied:

BGB	
grassland	**tdm/ha**
	4.55

Uncertainty associated with this parameter:

BGB	
SE (standard error)	4.82
90% CI [tdm/ha]	7.93
90% CI [%]	174.26

Parameter:	*AGB After j*
Description:	Above-ground biomass of the agroforest category
Data unit:	Ton of dry matter per hectare
Source of data or description of the method for developing the data including the	The biomass for cocoa-based agroforests comes from the study by Asigbaase et al., (2021), available at this link. In their methodological approach, they relied on an inventory of different agroforestry systems in Ghana. Using diameter at breast height (DBH) measurements in the allometric equation of Chave et al., (2014) for shade trees and Andrade et al., (2008) for cocoa.

<table>
<tr><td>spatial level of the data (local, regional, national, international):</td><td></td></tr>
<tr><td>Value applied:</td><td><table><tr><td></td><td>AGB</td></tr><tr><td rowspan="2">agroforest</td><td>tdm/ha</td></tr><tr><td>45.8</td></tr></table></td></tr>
<tr><td>QA/QC procedures applied</td><td>A literature review carried out on the theme related to the quantification of agroforestry systems was carried out in order to confirm our choice of the value applied above. Thus, taking the same approach in Ghana, Nimo et al., (2021) showed that agroforestry systems store around 74 tdm/ha. This difference results from the diversity of the forest species used but especially from the difference of the allometric equations.</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td><table><tr><td colspan="2">AGB</td></tr><tr><td>SE</td><td>2.6</td></tr><tr><td>90% CI [tdm/ha]</td><td>4.37</td></tr><tr><td>90% CI [%]</td><td>9.55</td></tr></table></td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

<table>
<tr><td>Parameter:</td><td>BGB After j</td></tr>
<tr><td>Description:</td><td>Belowground biomass of the agroforest category</td></tr>
<tr><td>Data unit:</td><td>Ton of dry matter per hectare</td></tr>
<tr><td>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</td><td>Belowground biomass was calculated by applying the AGB stem-to-root ratio (Cairns et al., 1997). The article is available at the following link.</td></tr>
<tr><td>Value applied:</td><td><table><tr><td>BGB</td></tr></table></td></tr>
</table>

	agroforest	tdm/ha	
		8.4	
QA/QC procedures applied	See AGB table agroforest		

	BGB	
Uncertainty associated with this parameter:	SE	0.66
	90% CI [tdm/ha]	1.11
	90% CI [%]	13.22
Any comment:		

Parameter:	BGB $_{After, RFreg}$
Description:	Removals in the BGB due to carbon sequestration due to creation of forest plantation
Data unit:	Ton of dry matter per hectare per year (tdm/ha)
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The root shoot ratio developed by MOKANY, KAREL & Raison, RJ & Prokushkin, Anatoly in 2005 was used: Critical analysis of root: Shoot ratios in terrestrial biomes. Available at this address.
Value applied:	

Category	BGB
	tdm/ha
Forest plantations / reforestation < 20 yrs	45.94
Forest plantations / reforestation > 20 yrs	100.8

QA/QC procedures applied	These data from the literature were confirmed by the MRV team in Côte d'Ivoire, which ensured the consistency of the values for the program area.
Uncertainty associated with this parameter:	(see table below)
Any comment:	

Parameter	BGB	
	Forest plantations / reforestation < 20 yrs	Forest plantations / reforestation > 20 yrs
90% CI [tdm/ha]	3.68	8.06
Relative error [%]	8	8

8.4 Estimated Reference Level

ER Program Reference level.

Crediting Period year *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)	Adjustment, if applicable (tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)
2016	7,692,979	1,779,971	-10,320	0	9,462,630
2017	7,692,979	1,779,971	-15,480	0	9,457,470
2018	7,692,979	1,779,971	-20,640	0	9,452,309
2019	7,692,979	1,779,971	-25,801	0	9,447,149
2020	7,692,979	1,779,971	-30,961	0	9,441,989
2021	7,692,979	1,779,971	-36,121	0	9,436,829
2022	7,692,979	1,779,971	-41,281	0	9,431,669
2023	7,692,979	1,779,971	-46,441	0	9,426,509
2024	7,692,979	1,779,971	-51,601	0	9,421,349
Total	69,236,809	16,019,741	-278,647	0	84,977,903

Calculation of the average annual historical emissions over the Reference Period

The updated average of the annual historical net emissions over the Reference Period is **9,441,989 tCO_{2-e}/yr**.

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

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

Not applicable because no upward adjustments have been considered.

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

Not applicable because no upward adjustments have been considered.

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

The ER-Program Forest Reference Level was developed following the methodology used to construct the national reference level submitted in January 2017 to the UNFCCC. The activity data used for the estimate of the FREL are a subset of the data used for the national level. However, a new land classification has been implemented to consider the definition of forest and its s categories contained in the forest code and the observations of the Committee of Participants in the Carbon Fund (See Section 9.1, Monitored Parameters: Area converted from forest type j to non-forest type i during the reference period 2000-2015).
In previous FRL, we had two categories, namely forest and non-forest. With the availability of new data and analysis tools, the two initial categories were disaggregated to better reflect activities on the ground. The following table shows the changes in land use classification between the 2017 reference level and the ERP reference level.

Land cover classification (FRL 2017)	**Revised Land Cover Classification (FRL ERP)**
Forest land	Dense Forest
	Secondary Forest
	Forest Plantation
	agroforest
non-forest	Cocoa Crops
	Perennial Crops
	Other Crops
	Grassland
	Human settlement
	Other land

This new land classification will also be used for the next update of the national FREL and for future GHG inventories in the Fourth National Communication. Regarding emission factors, those concerning categories not existing in previous work on the reference level were taken from the IFFN and national scientific articles.

9 APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

The original monitoring plan included a stratified random sampling approach using a land cover and land use change map, as Olofsson et al. (2014) recommended. Although this approach reduces change omission errors, they are still significant (McRoberts et al, 2018)[23]. To correct these errors and obtain relevant and precise results, a hybrid approach for estimating areas has been adopted; it incorporates the following characteristics:

- "Large" sample size: the sample size is sufficiently dense and stable over time (46415 sample points over the ER-Program area) to capture changes.
- Spatially balanced sampling between the different strata: the points of the different classes have the same weight;
- Hybrid machine/human interpretation to assign occupancy classes and changes: use of several change detection algorithms from several sources of satellite images and other spatially explicit information and visual interpretation;
- Principle of cross-validation, both for machine interpretation (convergence of evidence) and human interpretation (elimination of subjective bias);
- Quality control and quality assurance are integrated into all stages of the process.

This much more robust approach made it possible to obtain more relevant results and update the historical activity data and determine those for the monitoring period. It was planned to perform estimates of activity data using a stratified sampling approach every two years. However, with this new approach, activity data can be estimated annually.

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

Line diagrams

[23] McRoberts, et al. 2018. The effects of imperfect reference data on remote sensing-assisted estimators of land cover class proportions : https://doi.org/10.1016/j.isprsjprs.2018.06.002

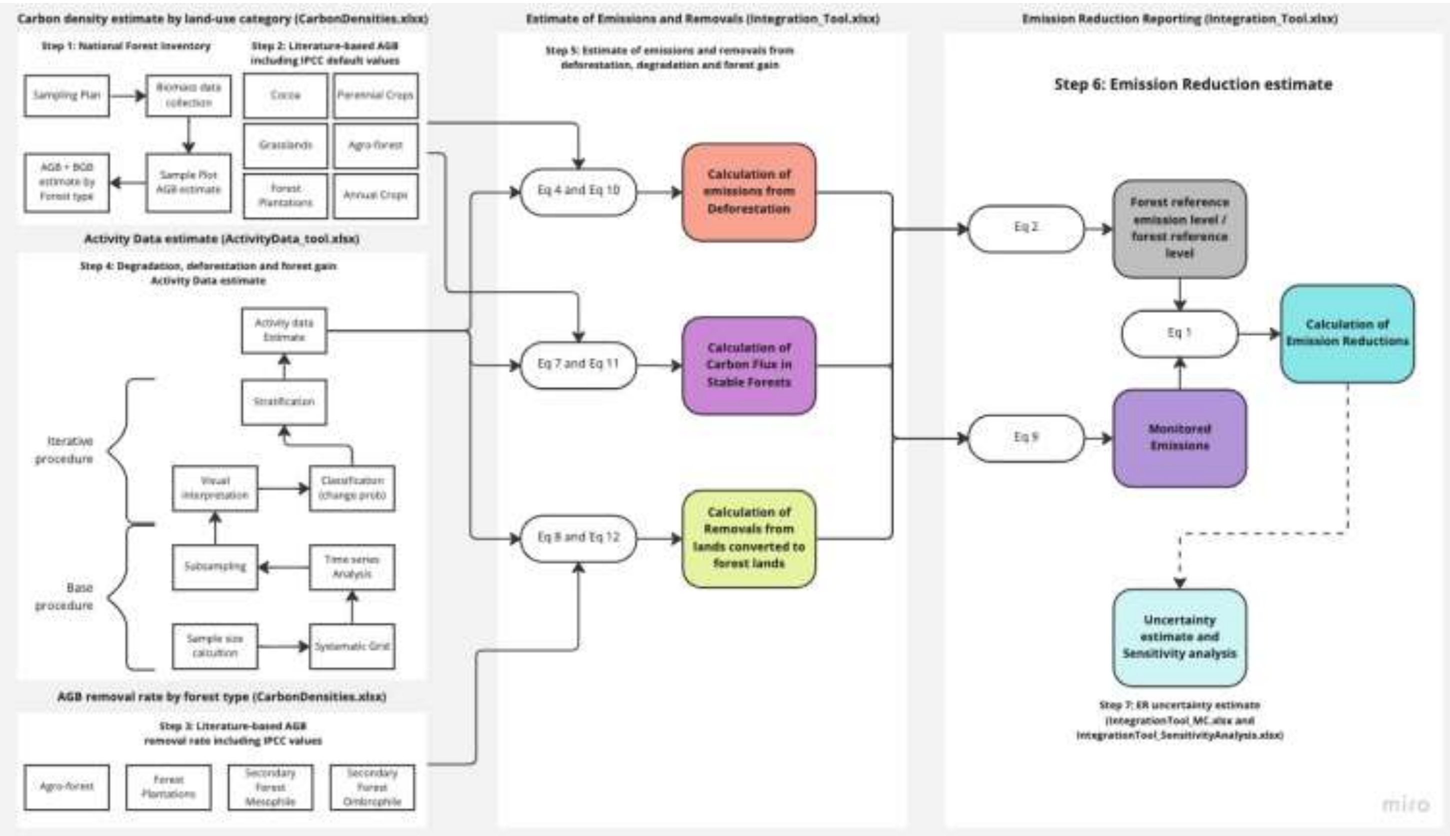


Figure 1: Line diagram for the GHG estimation.

Calculation steps

Monitored emissions ($\mathbf{GHG_t}$)

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 (ΔC_{B_t}).

$$GHG_t = \frac{\sum_t^T \Delta C_{LU_{MP,i,t}}}{T} \qquad \textbf{Equation 20}$$

Where:

$\Delta C_{LU_{MP,i,t}}$	=	Balance of emissions during the Monitoring Period in the Accounting Area of the ER Program that corresponds to the sum of annual change in carbon stocks and removals for each of i REDD+ activities at year t; tCO_2*$year^{-1}$.
T	=	Number of years during the monitoring period; dimensionless.

Annual change in total biomass carbon stocks forest land converted to another land-use category ($\Delta C_{B_{defo,t}}$)

The annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta \mathbf{C}_{\mathbf{B}_{defo,t}}$) would be estimated through **Equation 4** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_t} = \sum_{j,i} (B_{Before,j} - B_{After,i}) \text{ x } CF \text{ x} \frac{44}{12} \times A(j,i)_{RP}$$ ***Equation 21*** (Equation 2.16, 2006 IPCC GL)

Where:

$A(j,i)_{RP}$ Area converted/transited from forest type j to non-forest type *i* during the Reference Period, in hectares per year. In this case, twenty-four forest land conversions are possible:

1 Agro-forest to Cocoa
2 Agro-forest to Grassland
3 Agro-forest to Human settlement
4 Agro-forest to Other crops
5 Agro-forest to Other lands
6 Agro-forest to Perennial crops
7 Dense Forest to Cocoa
8 Dense Forest to Grassland
9 Dense Forest to Human settlement
10 Dense Forest to Other crops
11 Dense Forest to Other lands
12 Dense Forest to Perennial crops
13 Forest plantations / reforestation to Cocoa
14 Forest plantations / reforestation to Grassland
15 Forest plantations / reforestation to Human settlement
16 Forest plantations / reforestation to Other crops
17 Forest plantations / reforestation to Other lands
18 Forest plantations / reforestation to Perennial crops
19 Secondary Forest to Cocoa
20 Secondary Forest to Grassland
21 Secondary Forest to Human settlement
22 Secondary Forest to Other crops
23 Secondary Forest to Other lands
24 Secondary Forest to Perennial crops

$B_{Before,j}$ Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground ($AGB_{Before,j}$) and belowground biomass ($BGB_{Before,j}$) and it is defined for each forest type.

$B_{After,i}$ Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest IPCC Land Use categories.

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.

$44/12$ Conversion of C to CO_2

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta \boldsymbol{C_{B_{deg,t}}}$)

The Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta \boldsymbol{C_{B_{deg,t}}}$) would be estimated through **Equation 7** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_{DEG}} = \sum_{j} \{ EF_j \times A(a,b)_{MP} \}$$ **Equation 22**

Where:

EF_j	Emission factor for degradation of forest type a to forest type b, tones CO2 ha^{-1}.
$A(a,b)_{MP}$	Area of forest type a converted to forest type b (transition denoted by a,b) during the Monitoring Period, ha yr^{-1}.

Annual change in carbon stocks in biomass on non-forestland converted in forestland ($\Delta C_{B_{reg}}$)

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{reg}}$) would be estimated through **Equation 8** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

:

$$\Delta C_{B_{reg}} = \sum_{LU=1}^{n} \{ RF_{reg} \times A(i,j)_{MP} \}$$ **Equation 23**

Where:

RF_{reg}	enhancement of carbon stocks in new forests [tCO2*ha*year^{-1}].
$A(j,i)_{MP}$	Area of non-forestland *i* converted to forestland *j* (transition denoted by *i,j*) in the Monitoring Period, ha yr^{-1}.
LU	Land unit.

Parameters to be monitored

Parameter:	$A(j,i)$
Description:	*Area converted from forest type j to non-forest type i during the reference period (2000-2015).*
Data unit:	*Hectare per year.*
Value monitored during this Monitoring / Reporting Period:	*Ombrophile zone* *Table 1: Annual deforestation and degradation (ha/ year) in the ombrophile zone between 2000-2015*

Deforestation	From Dense Forest (DF) to Cocoa Crops (CC)	7337,16
	From Dense Forest (DF) to Perennial Crops (PC)	40,58
	From Dense Forest (DF) to Other Crops (OC)	1649,72
	From Dense Forest (DF) to Grassland (GG)	1258,74
	From Dense Forest (DF) to Human Settlement (HH)	40,58
	From Secondary Forest (SF) to Cocoa Crops (CC)	9277,40
	From Secondary Forest (SF) to Perennial Crops (PC)	1324,00
	From Secondary Forest (SF) to Other Crops (OC)	2663,89
	From Secondary Forest (SF) to Grassland (GG)	1428,39
	From Secondary Forest (SF) to Human Settlement (HH)	62,27
	From Secondary Forest (SF) to Other Lands (OL)	0,00
Degradation	From Dense Forest (DF) to Secondary Forest (SF)	5490.94
	From Dense Forest (DF) to Forest Plantation (PP)	0,00
	From Dense Forest (DF) to Agroforest (AF)	449,17
	From Secondary Forest (SF) to Agroforest (AF)	1627,94
	From Secondary Forest (SF) to Dense Forest (DF)	141,89

Mesophile zone

Table 2: Annual deforestation and degradation (ha/ year) in the mesophile zone between 2000-2015

Deforestation	From Dense Forest (DF) to Cocoa Crops (CC)	2090,77
	From Dense Forest (DF) to Perennial Crops (PC)	0,00
	From Dense Forest (DF) to Other Crops (OC)	275,43
	From Dense Forest (DF) to Grassland (GG)	350,64
	From Dense Forest (DF) to Human Settlement (HH)	00,00
	From Dense Forest (DF) to Other Lands (OL)	41,67
	From Secondary Forest (SF) to Cocoa Crops (CC)	3891,34
	From Secondary Forest (SF) to Perennial Crops (PC)	179,02
	From Secondary Forest (SF) to Other Crops (OC)	1605,26
	From Secondary Forest (SF) to Grassland (GG)	1109,14
	From Secondary Forest (SF) to Human Settlement (HH)	41,67
	From Secondary Forest (SF) to Other Lands (OL)	137,35
Degradation	From Dense Forest (DF) to Secondary Forest (SF)	1084,71
	From Dense Forest (DF) to Forest Plantation (PP)	0,00
	From Dense Forest (DF) to Agroforest (AF)	350,64
	From Secondary Forest (SF) to Agroforest (AF)	649,76

Table 3: Forest gain (ha) between 2000-2010 and 2010-2015

	2000-2010	*2010-2015*	
Ombrophile zone			
Secondary forest (SF)	*2128*	*3369*	
Agroforest (AF)	*-*	*9126*	
Mesophile zone			
Secondary forest (SF)	*1250*	*3936*	
Agroforestry (AF)	*1753*	*8056*	

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

The activity data used for the reference period was obtained from a sampling approach for estimating areas that incorporates the following characteristics:
A sufficiently dense and balanced sample size to capture changes in land cover classes.
Hybrid machine (algorithm) / human (visual) interpretation to assign land cover classes and changes: Several change detection algorithms, from several sources of satellite images and/or other spatially explicit information and visual interpretation were used to detect change classes.
Cross-validation principle, both for machine interpretation (convergence of evidence) and human interpretation (elimination of subjective bias). This required the formalization of decision rules.
Quality control and integrated quality assurance at all stages of the process.
5. The FAO technical team in charge of forest monitoring has developed tools to facilitate the design and implementation of this approach. All these tools and resources are available via this link: https://github.com/lecrabe/sbae_point_analysis_CIV

The figure below shows the different stages of the process:

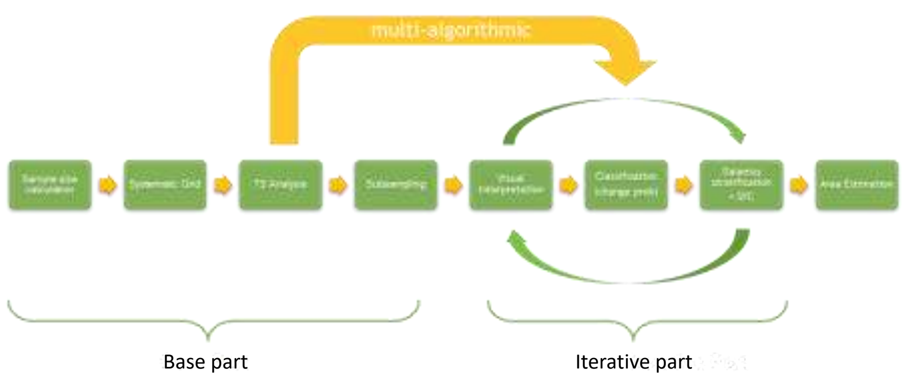


Figure 3: Steps in the methodological process for estimating activity data

Sampling design

An empirical analysis with a reference product (ESA CCI map 2015-2020) shows that a systematic sampling of 1km x 1km over the ERP area is required to capture the changes with a relative sampling error of less than 15% on the land cover change classes.
On this basis a rectangular systematic grid of 46,415 points was generated as illustrated in the figure below. The tool **erp_01_sbae_design** was developed to generate the samples.

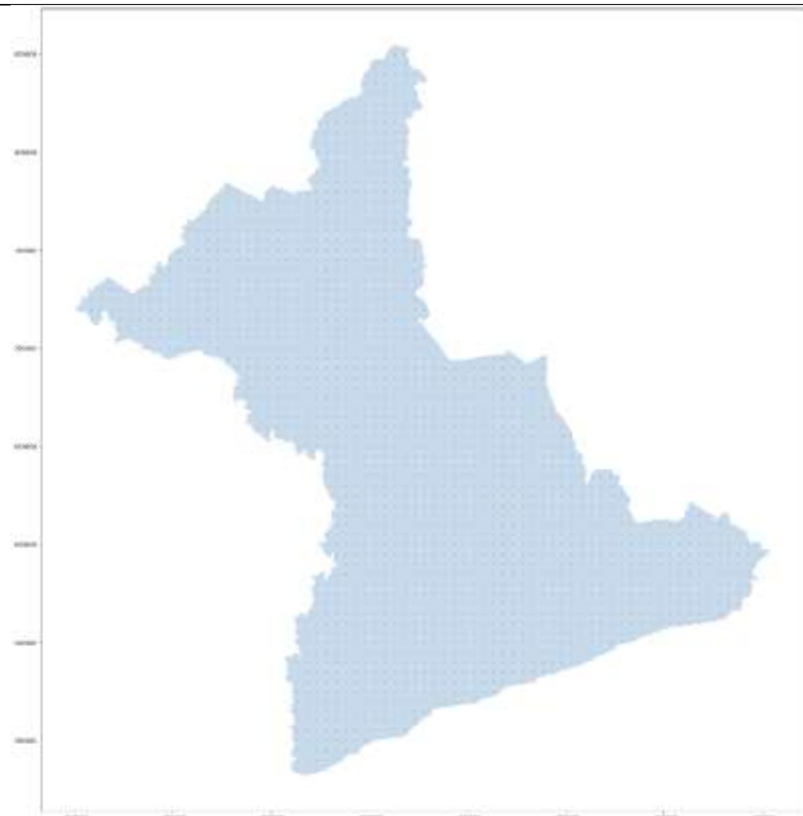


Figure 4: 1 sqkm grid adapted in the ERP

This established sampling system is stable over time and can be re-used for the regular updating of land cover change statistics.

Extraction of data (variables) from the assembly approach

Information from several global layers (TMF, GFC, ESA, DW, ESRI) is extracted for each of the points, as well as the normalized vegetation indices, from the entire Landsat archive. These index series are also analyzed with several algorithms (BFAST, CUSUM, CCDC, LandTrendR, and standard statistical descriptors). The list of variables used for this set approach is shown in the following table. These operations were performed using the notebook erp_02_extract_ts.

Name	Variables	Description	Reference	Link
Grid information	LON', 'LAT', 'PLOTID'	Coordinates and unique identifier of each point	Grid information	https://github.com/sepal-contrib/sbae_point_analysis

	SRTM DEM	aspect', 'elevation', 'slope'	Digital elevation model variables	Farr et *al.* 2007	https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2005RG000183
	Dynamic World	dw_class_mode', 'dw_tree_prob__max', 'dw_tree_prob__min', 'dw_tree_prob__stdDev', 'dw_tree_prob_mean'	Dominant Dynamic World land cover class and tree probabilities	Brown et *al.*, 2022	https://www.nature.com/articles/s41597-022-01307-4
	ESA LC 2020	esa_lc20'	Global land cover product at 10 m resolution for 2020 based on Sentinel-1 and 2 data	Zanaga et *al.* 2021	https://worldcover2020.esa.int/
	ESRI LC 2020	esri_lc20'	Sentinel-2 10m land cover time series of the world from 2017-2021	Karra, et *al.* 2021	https://www.arcgis.com/home/item.html?id=d3da5dd386d140cf93fc9ecbf8da5e31
	GFC	gfc_gain', 'gfc_loss', 'gfc_lossyear', 'gfc_tc00'	Global Forest Change variables	Hansen et al. 2013	https://earthenginepartners.appspot.com/science-2013-global-forest
	Canopy height model	lang_tree_height'	Tree height	Lang et al., 2022	https://arxiv.org/abs/2204.08322
	Forest canopy height	potapov_tree_height'	Tree height	Potapov et al., 2020	https://www.sciencedirect.com/science/article/pii/S0034425720305381

	TMF	tmf_20xx' .. 'tmf_20yy', 'tmf_defyear', 'tmf_degyear', 'tmf_main', 'tmf_sub'	Tropical Moist Forest variables, including yearly land cover	Vancutsem et al., 2021	https://www.science.org/doi/10.1126/sciadv.abe1603
	Landsat Time series	dates', 'ts', 'images', 'mon_images'	Dates, spectral values and total number of USGS Landsat 4 to 9 acquisitions, Level 2, Collection 2, Tier 1	USGS, 2008	https://www.usgs.gov/landsat-missions/landsat-collection-2-level-1-data
	CCDC	ccdc_change_date', 'ccdc_magnitude'	Continuous change detection and classification of land cover using all available Landsat data	Zhu and Woodock, 2014	https://www.sciencedirect.com/science/article/pii/S0034425714000248
	LandTrendR	ltr_magnitude', 'ltr_dur', 'ltr_yod', 'ltr_rate', 'ltr_end_year'	Temporal segmentation for forest disturbance and recovery	Kennedy et al., 2010	https://www.sciencedirect.com/science/article/pii/S0034425710002245
	BFAST	bfast_change_date', 'bfast_magnitu	Near real-time disturb	Verbesselt et al., 2013	https://www.sciencedirect.com/science/article/pii/S003442571200115O?via%3Dihub

	de', 'bfast_means'	ance detection using satellite image time series		
CUSUM	cusum_change_date', 'cusum_confidence', 'cusum_magnitude'	Cumulative Sum Test to Detect Land-Cover Changes	Kellndorfer, etal. 2019	https://gis1.servirglobal.net/TrainingMaterials/SAR/Ch3-Content.pdf
TS metrics	ts_mean', 'ts_sd', 'ts_min', 'ts_max'	Basic statistical metrics describing the time series	Vollrath, unpublished	https://github.com/sepal-contrib/sbae_point_analysis
Bootstrap	bs_slope_mean', 'bs_slope_sd', 'bs_slope_max', 'bs_slope_min'	Basic statistical metrics describing the trend of the time series	Vollrath, unpublished	https://github.com/sepal-contrib/sbae_point_analysis

Using the tool erp_02_extract_ts.made it possible to associate the information above with each sample.

Unsupervised aggregation of points

The information is injected into a cluster model that identifies points with similar trajectories for the different products. The clusters have different sizes, and correspond to homogeneous groupings of points, a priori distinguishing between change points and stable points. The goal is to make an unsupervised classification of the information on the points, to have different a priori batches of points with different trajectories of change. This allows points to be selected from all clusters to have a representative training dataset to be interpreted.

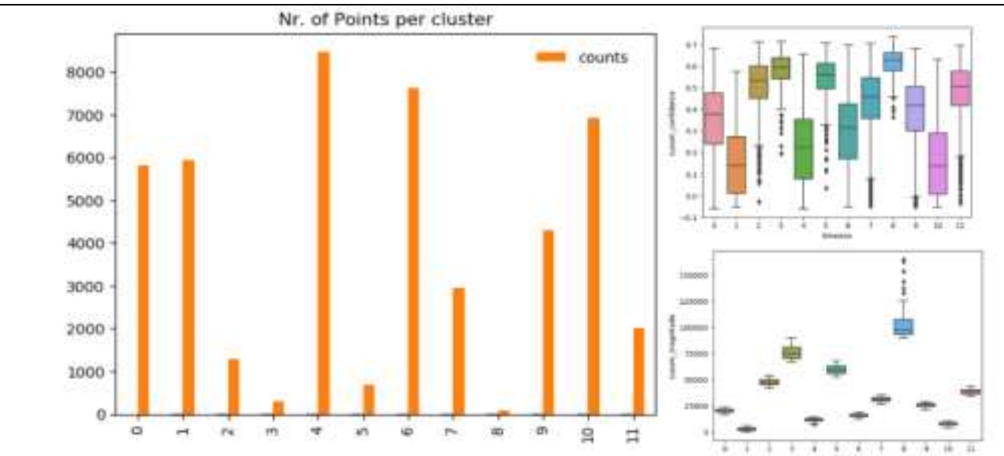


Figure 5 : Unsupervised cluster analysis (12 clusters 30 pts max / cluster 339 points)

The next step is to draw a small number of points (here ~30) in each of the clusters (339 in total) to produce a training dataset with descriptive variables of land use status and trends. https://app.collect.earth/collection?projectId=32912

A project has been generated to collect this information by visual interpretation.

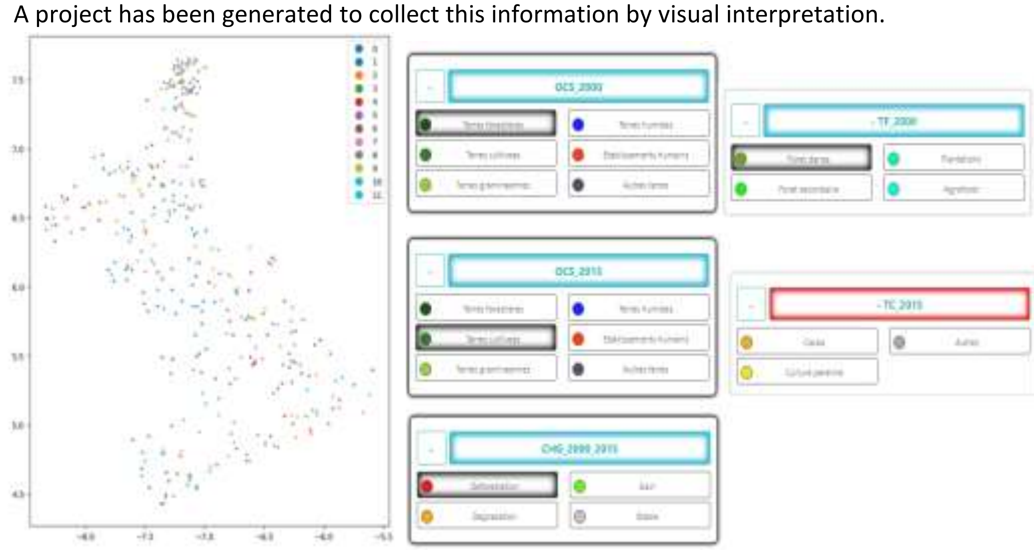


Figure 6: First interpreted dataset and survey form.

The collection of this reduced set of points is also an opportunity to check the robustness of the interpretation keys.

Supervised classification 1

CLUSTER	0	1	2	3	4	5	6	7	8	9	10	11
Deforestation	8	5	10	11	14	8	1	16	3	10	13	12
Degradation	1	0	1	1	0	0	2	0	0	1	0	0
Stable	21	25	19	18	16	22	27	14	6	19	17	18
Prop. Defor.	27%	17%	33%	37%	47%	27%	3%	53%	33%	33%	43%	40%
Total	7298	4372	1874	7617	1863	129	6187	8657	9	2953	5800	454

```
Maximum probability of stable for change points
0.8421333333333332
Reasonable probability of stable for change points
0.49840000000000006
Number of points above thshld (considered stable)
235 out of 339
Number of actual change points left in stable
11
```

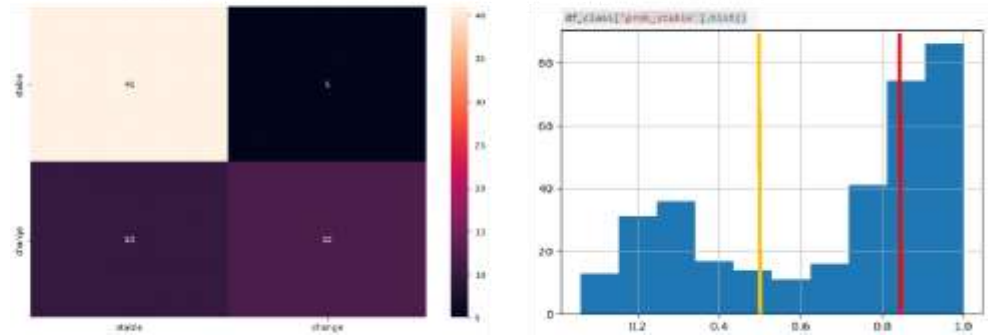


Figure 7 : Distribution of probabilities of being stable in the interpreted data set (339 points)

The data is then used to perform a supervised classification of the set of points with respect to land use change types.

Figure 7 illustrates the results of the supervised classification with two classes (deforestation and stable), through the distribution of the probabilities of being stable, for each of the 339 points. The red bar indicates the probability threshold (0.84) beyond which no change points were recorded and the yellow bar indicates the 90% percentile (probability of 0.49). The 339 sample points were considered statistically insufficient to represent the entire sample.

To address this shortcoming a second training dataset with a number of points was determined based on the approach described by Hidiroglou, M.A. and Kozak, M. (2018) and Dalenius, T. and Hodges Jr, J.L.(1957). It increases the precision of estimates by assigning different sampling fractions to strata. For this dataset, we have 692 samples (Figure 8).

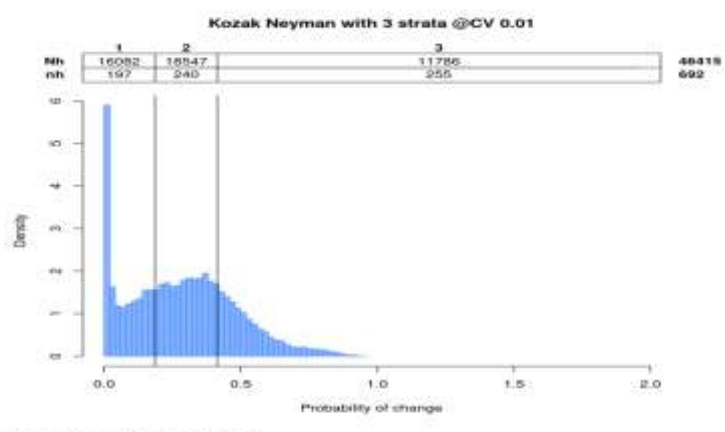


Figure 8: Change probability de changement according to Kozak Neyman

Supervised classification 2

The dataset of 692 points was interpreted according to the selection in the previous figure in order to serve as training for supervised classification using the *Random Forest* algorithm.

This classification gives a good distribution and confirms the good representativeness of the 692 points in relation to the whole.

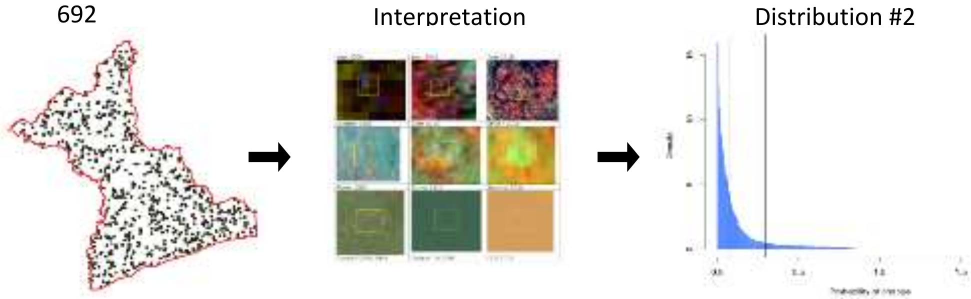


Figure 9: Supervised classification to achieve better class separation.

Final selection

Using the actual observed variance of the 692 points already interpreted, the combined Dalenius - Neyman method with 3 strata could be applied to arrive at the final selection of 3308 points, i.e. a total of 4000 points (with 692 points already interpreted) as illustrated in Figure 10. below.

These points were then interpreted in order to obtain the different classes of change in the ERP area over the period 2000 to 2021, thus covering the reference period (2000-2015) and the monitoring period (2020-2021).

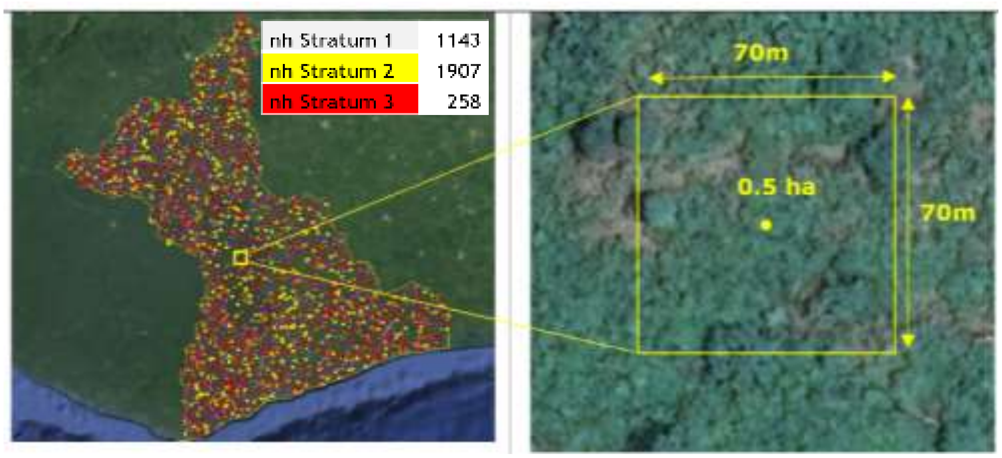


Figure 10 : Final Sample and exemple of a sample point

Sample Interpretation

The interpretation rules mentioned above were then presented and implemented during a workshop held in Paris, France from December 12 to 16, 2022 with the presence of IGN FI, World Bank and SEP REDD+ teams. This workshop helped harmonize the interpretations and reduce the margins of uncertainty. Following this workshop, all 4,000 selected points were interpreted. An analysis of the disagreements between interpretations was made possible by the double interpretation of the 692 points.

Following the analysis of the disagreements on the 692 points, it was necessary to perform a more thorough quality control in order to reduce the potential errors of interpretation as much as possible. Therefore, the points on which at least one change had been detected during the period 2000-2015 and 2020-2021 were reinterpreted representing 995 samples out of a total of 4,000.

Statistical analysis

All 4,000 samples, including those that were reinterpreted, were used as the basis for calculating area estimates and their uncertainty.
The estimation of activity data was done using the stratified random estimator based on the formulas described by Cochran (1977) and GFOI (2020). Estimates are made for each of the land use categories considered (11 classes) and in terms of changes from one period to another representing a total of more than 60 effective combinations.
Estimates and associated uncertainties are produced for each combination and for each phytogeographic zone (Mesophilic, Ombrophilic and Sub-Sudanian) considering the stratification applied. A detailed description of the calculation methods is available in the SOP_4_Data analysis_RCI.docx document.

QA/QC procedures applied:

The QA/QC procedures applied consisted of:

First, standard operating procedures (SOPs) were developed as described in section 2.1

Interpretation was done by highly qualified professionals from the *Ingénierie Géographique Numérique Française à l'International* (IGN-FI based in France) who are specialized in the interpretation of land cover with satellite imagery.

Also, a cross-interpretation of the first series of sample points (692) was carried out by expert photo-interpreters from IGN-FI who had not taken part in the first interpretation and the MRV experts from SEP REDD+.

This step made it possible to assess the accuracy and bias of the photointerpretation to ensure better calibration. Following the analysis of the disagreements of the cross-interpretation, it appeared necessary to reinterpret a little less than 1000 samples in order to minimize the potential interpretation errors.

The statistics associated with the different land use changes to determine the Activity Data were carried out by IGN-FI. The accuracy of the calculations and formulas used were independently verified by the FAO using an experienced statistician.

Uncertainty for this parameter:

Quantification of uncertainties over the reference period (2000-2015)

	Mesophile			Ombrophile		
Land cover change categories	**Estimation average (ha/an)**	**Confidence Interval 90% (ha)**	**Confidence Interval %**	**Estimation average (ha/an)**	**Confidence Interval 90% (ha)**	**Confidence Interval %**
Deforestation						
Agroforest (AF) to cocoa crops (CC)	621,15	461,34	73,76%	876,38	607,07	69,05%

	Agroforest (AF) to Grassland (GG)	83,35	136,99	164,35%	81,15	133,38	164,35%
	Agroforest (AF) to Other Crops (OC)	333,39	271,06	87,57%	263,62	336,96	127,39%
	Agroforest (AF) to Human Settlement (HH)				81,15	94,28	116,18%
	Dense Forest (DF) to Cocoa Crops (CC)	2090,77	792,79	45,20%	7337,16	1410,39	20,04%
	Dense Forest (DF) to Perennial Crops (PC)				40,58	66,69	164,35%
	Dense Forest (DF) to Other Crops (OC)	275,43	267,57	111,56%	1649,72	734,84	44,65%
	Dense Forest (DF) to Grassland (GG)	350,64	364,21	69,25%	1258,74	611,60	48,15%
	Dense Forest (DF) to Human Settlement (HH)				40,58	66,69	164,35%
	Dense Forest (DF) to Other Land (OL)	41,67	68,49	164,35%			
	Secondary Forest (SF) to Cocoa Crops (CC)	3891,34	1192,55	30,46%	9277,40	1882,44	20,86%
	Secondary Forest (SF) to Perennial Crops (PC)	179,02	236,02	131,84%	1324,00	715,35	52,42%
	Secondary Forest (SF) to Other Crops (OC)	1605,26	802,83	47,41%	2663,89	937,93	35,34%
	Secondary Forest (SF) to Grassland (GG)	1109,14	649,22	61,56%	1428,39	713,18	49,05%
	Secondary Forest (SF) to Human Settlement (HH)	41,67	68,49	164,35%	62,27	102,38	164,40%
	Secondary Forest (SF) to Other Land (OL)	137,35	225,86	164,45%			
	Degradation						
	Dense Forest (DF) to Agroforest (AF)	350,64	319,54	94,26%	449,17	336,07	74,82%
	Dense Forest (DF) to Secondary Forest (SF)	1084,71	675,55	72,34%	5490,94	1340,28	28,69%
	Secondary Forest (SF) to Agroforest (AF)	649,76	536,57	81,51%	1627,94	887,69	58,69%

Gain
2000-2010

	(see tables below)
Any comment:	

	Area (ha)	**Confidence Interval 90% (ha)**	**Confidence Interval (%)**
Ombrophile zone			
Secondary forest (SF)	*2128,35*	*3499.99*	*164.45*
Mesophile zone			
Secondary forest (SF)	*1250,22*	*1451.70*	*116,12%*
Agroforest (AF)	*1753.20*	*2120.26*	*120.94*

2010-2015			
	Area (ha)	**Confidence Interval 90% (ha)**	**Confidence Interval (%)**
Ombrophile zone			
Secondary forest (SF)	*3 368,75*	*2 520,55*	*74,82%*
Agroforest (AF)	*9 125,96*	*5 696,04*	*62,42%*
Mesophile zone			
Secondary forest (SF)	*3 935,53*	*3 825,39*	*97,20%*
Agroforest (AF)	*8 055,94*	*6 113,77*	*75,89%*

Parameter:	*A(j,i)*
Description:	*Area converted from forest type j to non-forest type i during the monitoring period (2020-2021).*
Data unit:	*Hectare per year*
Value monitored during this Monitoring / Reporting Period:	*Ombrophile Zone*

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

See description for the reference period

Deforestation	*From Agroforest (AF) to Cocoa Crops (CC)*	1217.32
	From Agroforest (AF) to Other Crops (OC)	608.66
	From Agroforest (AF) to Human Settlement (HH)	608.66
	From Secondary Forest (SF) to Human Settlement (HH)	608.66
	From Secondary Forest (SF) to Other Crops (OC)	608.66
Degradation	*From Dense Forest (DF) to Secondary Forest (SF)*	*2128.35*
Gain	*Agroforest (AF)*	*3085.55*

QA/QC procedures applied:

See description for the reference period

Mesophile zone

Deforestation	*From Agroforest (AF) to Cocoa Crops (CC)*	625,11
	From Agroforest (AF) to Other Crops (OC)	625,11
	From Secondary Forest (SF) to Other Crops (OC)	2060.20

Uncertainty for this parameter:

Quantification of uncertainties over the reference period (2020-2021)

Land cover change categories	Mesophile			Ombrophile		
	Estimation average (ha/an)	**Confidence Interval (CI) 90% (ha)**	**Confidence Interval %**	**Estimation average (ha/an)**	**Confidence Interval 90% (ha)**	**Confidence Interval %**
Deforestation						
Agroforest (AF) to cocoa crops (CC)	625,11	1 027	164,4%	1 217,32	1 414	116,2%
Agroforest (AF) to Other Crops (OC)	625,11	1 027	164,4%	608,66	1 000	164,3%
Agroforest (AF) to Human Settlement (HH)				608,66	1 000	164,3%
Secondary Forest (SF) to Other Crops (OC)	2 060,20	3 388	164,4%	608,66	1 000	164,3%
Secondary Forest (SF) to Human Settlement (HH)				608,66	1 000	164,3%
Degradation						
Secondary Forest (SF) to Agroforest (AF)	2 060,20	3 388	164,4%			
Dense Forest (DF) to Secondary Forest (SF)				2 128,35	3 500	164,4%
Gain						
Agroforest (AF)	2 060,20	3 388	164,4%	3 085,55	2 589	83,9%

Any comment:

9.2 Organizational structure for measurement, monitoring and reporting

The monitoring system, whose role is to assess the country's performance in reducing emissions from deforestation and forest degradation, is implemented with several national actors according to their fields of competence.
In Côte d'Ivoire, SEP-REDD+ has the lead on National Forest Monitoring System (NFMS) activities. As such, it coordinates the work of stakeholder organisations, both at the national level and in the ERP zone, for (i) estimating data on land use change activities, (ii) estimating biomass and emission factors for the different relevant vegetation strata, (iii) estimating GHG emissions/removals due to REDD+ activities, and (iv) notifying GHGI to partners for verification.
The organisations in charge of producing activity data are:

- BNETD/CIGN is the national reference centre for map production (topographic maps and thematic maps). It produces mapping data and develops geographic information systems necessary for the study, implementation and operation of land use planning. It coordinates and controls mapping and remote sensing work on behalf of the State of Côte d'Ivoire. In general, these are "wall-to-wall" maps that are produced from satellite image processing coupled with data collection campaigns in the field;
- CNTIG which is responsible for defining policy, organising and coordinating programmes in the field of geoinformation and applied remote sensing;
- SODEFOR is the entity responsible for providing data (geographical, socio-economic, and other statistics) related to the sustainable management of classified forests;
- OIPR is responsible for providing data (geographical, socio-economic, and other statistics) related to the management of parks and reserves;
- SEP-REDD+ is responsible for the compilation, quality control and archiving of data collected by national entities and the estimation of uncertainties associated with the surface areas of the strata
- Universities and research centres (CURAT, IGT, CNF, CSRS and INPHB) contribute to the development of methodologies and quality control of data collected by other organisations producing data on activities. In addition, the data ;

The organisations in charge of producing data on biomass and emission factors are:

- The Ministry in charge of forests (MINEF) which is the national organisation in charge of carrying out forest and wildlife inventories. As such, a national inventory of forest and wildlife resources was carried out between 2019 and 2021, in partnership with SODEFOR, OIPR and ANADER;
- SEP-REDD+, which in 2016, in partnership with SODEFOR, conducted a forest inventory to estimate the biomass of forests;
- SODEFOR, which collects dendrometric data as part of the development inventories of the classified forests under its management;
- Universities and research centres which, as part of their research work, collect dendrometric data in various ecosystems, both forest and agricultural, which are used to estimate emission factors. They also participate in the quality control of the data collected by the above-mentioned entities.

The estimation of GHG emissions/removals and emission reductions achieved from the implementation of projects and other policies on land use/land cover changes is the responsibility of SEP-REDD+.

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

The data used for the GHG inventory come, as indicated in the previous paragraph, from different sources. The choice of data to be used depends on a number of factors including: (i) the spatial and temporal coverage of the data, (ii) the suitability of the methodology used for its production and standard operating procedures.
National data are preferred when they meet the above conditions. Otherwise, or in the absence of relevant national data, data are sought from relevant international databases.
For the same category of data, the data are compiled, cleaned, consolidated and archived in databases designed for this purpose and available on the SEP-REDD+ servers. This makes it possible to make them accessible later for processing but also and above all for any verifications that may be necessary.
Thus, the mapping data used for the calculation of the country's emissions or the ERP were produced by BNETD/CIGN following a methodology validated at the national level by the various stakeholders such as universities, research centres and competent national organisations. This methodology also includes the process of validation of the data produced, which meets national and international standards.

Missing biomass data are selected based on different sources of information such as research results conducted in the country or in the sub-region and published, e.g. the values used for agroforestry and cocoa biomass.

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

Initially, for the production of activity data, data collection was carried out by BNETD/CIGN with the participation of other organisations such as CNTIG, SODEFOR, OIPR and universities and research centres (CURAT, IGT).

This data collection was carried out at two levels: the collection of satellite images on download sites and the collection of field data to serve as training data for classification algorithms. The data produced underwent validation at national level before publication. This validation consisted of photo-interpretation, using tools such as Collect Earth or free open-source mapping software of sample units produced according to a stratified random design.

However, it should be noted that the methodology for estimating the AD have been improved in terms of the type of sampling and its size. This change is in response to technological developments in data, tools, and new technical considerations (Pagliarella, 2017[24]; McRoberts et al., 2018[25]).

Indeed, accurate and precise estimates of land cover/land use change area are essential to compare and measure the effect of policies and activities to mitigate, adapt or prevent the effect of climate change. However, individual maps contain errors which, when combined to make land cover area estimates, increase bias, and prevent the characterisation of land use change to the standards required by the international community.

The methodological approach developed in 2018 for the ERPD described area estimates through a combination of data based on visual interpretation of sampling units and the use of maps. In practice, it consisted of using classified and combined maps to design a reference sample according to the practices described by Olofsson (2013[26], 2014[27]). This approach used by SEP REDD+ in 2018 for the FREL development of the ERP was updated in late October 2022 with support from the World Bank, FAO and the Institut Géographique National-France International (IGN- FI), with a view to measuring reduced emissions in a robust and more accurate way.

In the new approach, the interpreted sampling units for the estimation of land use change areas are distributed according to a systematic sampling grid spaced at 1 km, which leads to a very dense sampling design (i.e. 46415 points () over the ERP area, 4000 of which are intended for visual and fixed interpretation, i.e. the same sampling will be used for the collection of past and future data. In order to harmonise the interpretations between the different operators and to reduce as much as possible the interpretation errors that could induce noise in the results, the process of sampling unit visual interpretation has been standardised by developing interpretation keys (link available here)

To carry out the data collection, a joint mission of the World Bank, FAO, IGN FI and SEP-REDD+ was organised in Paris, France from 12 to 16 December 2022. The objective of that mission was the production of the ERP activity data in order to elaborate the project's reduced emissions monitoring report.

The information on emission/absorption factors comes from the 2016 national forest inventory conducted by MINEDD through SEP-REDD+ and SODEFOR.

- **Systems and processes that ensure the accuracy of data and information.**

Various processes and systems are in place to ensure the accuracy of the data and information produced by the MRV system. These are:

- The implementation of QA/QC processes in all data production processes;
- The development of standard operating procedures (SOPs) for the collection, processing, archiving and management of data. They are described in detail in the following paragraphs;

[24]Pagliarella, et al. 2018. Spatially-balanced sampling versus unbalanced stratified sampling for assessing forest change: evidences in favor of spatial balance. https://sci-hub.wf/10.1007/s10651-017-0378-y

[25]McRoberts, et al. 2018. The effects of imperfect reference data on remote sensing-assisted estimators of land cover class proportions. https://sci-hub.wf/10.1016/j.isprsjprs.2018.06.002

[26]Olofsson, et al. 2013. Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation. https://sci-hub.wf/10.1016/j.rse.2012.10.031

[27]Olofsson, et al. 2014. Good practices for estimating area and assessing accuracy of land change. https://sci-hub.wf/10.1016/j.rse.2014.02.015

- Capacity building of national organisations in the implementation of standard procedures for the production of data and information in their field.

This offers the advantage of having more or less consistent data between them and which even when they are produced for smaller scales can be aggregated between them.
The Côte d'Ivoire MRV team received technical support from experts from the World Bank, FAO and the Institut Géographique National France International (IGN-FI). The experience gained from this collaboration will allow the reproducibility of data for future reporting periods in complete autonomy.

- **Design and maintenance of the Forest Monitoring System**

Côte d'Ivoire has received financial support from the C2D and the World Bank for the establishment of its Spatial Land Monitoring system. A geoportal (http://www.geoportailsst.com/) has been developed within this framework and improvements are in progress in order to allow the consultation of data and emission factors by stakeholders and the general public. This portal is managed by the SEP-REDD+ and maintained by the CNTIG.
It should be noted that this system is in the reorganization phase and will be finalized in May 2023 for the integration of new functionalities meeting user expectations in terms of MRV, information on social and environmental safeguards as well as the register of projects and REDD+ initiatives.

- **Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures (SOPs) and QA/QC procedures**

The daily management of classified forests is carried out by SODEFOR. While that of the rural domain is carried out by the MINEF. It should also be noted that the parks and reserves are monitored and administered by the OIPR. All these structures are responsible for carrying out forest monitoring actions in their respective areas of intervention.
For Quality Assurance and Quality Control, Standard Operating Procedures (SOPs) have been produced on the Sampling, Response and Analysis System available through this link.
They constitute a guide allowing the respect of the quality in the estimate of the DA but also in the replication of the processes. These different SOPs make it possible to successively describe the following steps:

SOP1: Design of the sampling plan
SOP2: Response system
SOP3: Baseline data collection
SOP4: Analysis system

A field data collection manual has been designed for compliance with forest inventory data collection procedures in addition to field verification. This manual is available here.

9.3 Relation and consistency with the National Forest Monitoring System

All procedures and methodologies to produce ADs and EFs are defined and validated at national level by all actors in the NFMS. The methodologies designed by these groups are the same and respond to the local and international context and the roles and responsibilities of the different national organisations remain identical.

The map captions have been harmonised and are used by all the national organisations in their various productions (land use maps and NFWI).

The collection procedures on EFs are the same used at national and sub-national level. It is worth recalling that the procedure for producing ADs recently updated with the support of the World Bank, FAO and IGN-FI, is the one that will be used for the next determinations of ADs both at the sub-national and national levels in the framework of the development of FRELs.

12 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

12.1 Identification and assessment of sources of uncertainty

Sources of uncertainty	Analysis of contribution to overall uncertainty
Activity Data	
Measurement	The identification of the 4000 points was carried out by visual interpretation of the satellite images. For each point and on each reference date (2000, 2005, 2010, 2015, 2020), a land cover class code was assigned according to the 11 classes defined in the nomenclature (to refer to SOP_2-response design). The photo-interpreter should especially indicate whether the nature of the point has changed over time if there has been a real land cover / land use changes at that location. Photointerpretation is a probabilistic science whose certainty of the choice of the land cover / use class can vary according to the difficulty of identifying this class. Indeed, a land cover class is characterized by its color, size, shape, structure, texture, and its arrangement with neighboring objects. On a satellite image, an object class can appear under different colors and shapes and the same color can belong to different land cover classes. The same class can be represented by several colors depending on the nature of the soil and the nature, structure, and composition of the vegetation cover. Moreover, in tropical and subtropical regions seasonality phenomena have a strong influence on the radiometry and spectral signature of biophysical objects, which sometimes can be confused and considered as a real change of land cover/land use between two dates. The difficulties to interpret these land cover classes can lead to confusions between the 11 land cover classes which are summarized in the confusion matrices provided in the FORM 3_Data collection_RCI_V2. Interpretation difficulties may be more prevalent for some land cover classes. As seen from the confusion matrices provided in FORM 3_Data collection_RCI_V2. In the forest classes (class 11, 12, 13, 14), it is obviously the mixed heterogeneous classes where the confusions are the most important especially the transition forest class (class 12) and agroforestry (class 14). Agroforestry (class 14) is a complex system composed of an association of forest species forming a tree layer and shrubby / perennial crops (including palm trees) and/or rainfed crops. In Ivory coast a cocoa plot (class 21) with tree cover will be assigned to this class and the tree density should be comprised between 20% and 70%. Concerning the secondary forest (class 12), the tree crowns are no longer joined but are still important and are still made up of local natural tree species. The tree density should be comprised between 30% and 70% resulting from degradation of a natural forest or regeneration or a secondary status to a forest stage. Hence, the difference between these two classes (class 12 and class 14) concerns the lower strata of shrub and grass and therefore whether this stratum is cultivated or not. The confusion of these two classes is understandable. In a few cases some confusion between class 12 secondary woodland and class 50 Grass, scrub and shrub land have been found. This class 50 refers to a mixed formations composed of grassy, shrubs and thickets stratum.

Sources of uncertainty	**Analysis of contribution to overall uncertainty**
	The shrub layer may be more or less dense and associated with scattered trees and according to the density of trees, this class could be confused with class 12. Less fundamental to the ERP but quite frequent are the confusions between the cropping systems (class 21, 22, 23) and class 50 Grass, scrub and shrub land. Indeed, these shrubby formations may be the result of natural regeneration of agricultural land through rotation or shifting cultivation. According to the age of the fallow land (old or young fallow land) confusion between these two classes (class 12 and class 50) may be possible.
Representativeness	Sampling was carried out over the entire study area and all reference and monitoring periods. It can therefore be concluded that the impact of this source of uncertainty is low.
Sampling	The sampling method is probabilistic based on a stratified approach with an optimal allocation of samples by strata by strata according to Neyman's method on the basis of a first sub-sample to estimate the variance of each stratum in order to estimate the variance of each stratum in terms of characterization of changes. However, the changes are numerous, diffuse and individually cover relatively small areas in the study area. Therefore, they are difficult to characterize and despite the collection of large number of samples, some categories of change show high variance. The selection of the estimator follows the recommendations of Cochran (1977) and the GFOI MGD (2020).
Extrapolation	The estimates were made on the basis of the samples collected and for which the interpretation of the land cover classes are exhaustive and cover the whole reference and monitoring periods. This source of error is therefore unlikely to be present in the approach adopted.
Approach 3	The approach adopted is a sampling approach that allows the monitoring of land use conversions on a spatially explicit basis. The interpretation rules as well as the applied QA/QC do not only focus on the allocation of a land use class to a given period but also ensure that the sequences detected over the different periods are consistent
Emission factor	
DBH measurement	In order to guarantee the quality of data, the following QA/QC procedures have been applied: • Design of a field data collection manual to serve as a guide https://drive.google.com/file/d/1Lm3a-JaKZ4cKUlIL68A21PTE1ycd43RT/view?usp=share_link ; • Training of data collection teams; • Conducting a pilot phase that allowed teams to understand the collection process; • Field data collection in 2 formats, paper (field sheet) and digital (tablets on which the Collect tool was installed); • Verification of the conformity of the data collected on the field sheets and tablets, allowing for corrections if necessary;
H measurement	

Sources of uncertainty	Analysis of contribution to overall uncertainty
	• The creation of 2 mixed teams for on-site verification of 8% of the total sample units already inventoried. These teams were made up of SEP-REDD+, universities and research centers, and civil society organizations. • Data cleaning based on a cross-check between the 2 information sources (digital file and paper format) allowed for error correction.
Plot delineation	Sampling units are clusters of 500 m x 500 m consisting of four rectangular observation plots of 25 m x 200 m. Each SU thus covers an area of 25 hectares. The coordinates of the center of these units correspond to those of the points on the survey plan. The inventory teams were trained in delimiting and installing the sampling units. Tools such as GPS, compasses, and marking equipment were used for this purpose. All procedures are described in the inventory guide.
Wood density estimation	The allometric equation for biomass prediction involves the specific wood density. A correspondence to obtain wood densities of these species has been established based on tree measurements. For each species, a correspondence is sought in the Global Wood Density Database and a mean wood density is associated with each tree, at the lowest level (species, genus or family). For all trees whose scientific names do not correspond or do not have known scientific names, a default value of the basic wood density of 0.58 g.m-3 which is the average value for tropical Africa (Reyes et al., 1992). This concerned exactly 14,376 listed trees.
Biomass allometric model	In the absence of allometric equations specific to forest formations in Côte d'Ivoire, the use of Globallometry has been put to use. The estimation of above-ground biomass (AGB) was made using a pantropical allometric equation. Queries made in the Globallometree database showed that at least 73 allometric equations are specific to Côte d'Ivoire. Most of these equations are specific to forest plantations (Teak, Gmelina, Acacia, etc.) and/or certain timber and woodworking species (Mahogany, Niangon, etc.). However, these equations are not suitable for national-scale application and all phytogeographic zones of the country. In order to represent all types of forests, the pantropical allometric equation (4) developed by Chave et al. (2014) was used to convert field measurements into estimates of above-ground biomass as it is estimated to be more robust and includes data from other pantropical equations including Brown's equation (1997), Chave's equation (2005) and Fayolle's equation (2013). This equation includes tree data from Africa. It is based on diameter at breast height (DBH), tree height, and wood basic density. This process is described in the biomass study report.
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	The QA/QC process applied to biomass from the literature consisted first of a comparison with results from other authors who worked under the same conditions and ecological zones. The idea here is to ensure that the results are substantially similar. Then a check of the calculations was carried out by redoing the calculations. The objective is to obtain the same values as the author using their data.

Sources of uncertainty	Analysis of contribution to overall uncertainty
Representativeness	Data used within ERP are at the Tier 2 level (country-specific data) and come from the national forest inventory of 2017 for forests (dense and secondary forest of the ombrophilic sector; dense and secondary forest of the mesophilic sector). There are a total of 150 sample units, each with 4 plots, for a total of 600 plots. The data are sufficiently representative of the program area and have allowed for precise estimates of emission factors. Details can be found in section 3.1 and via this link.
Integration	
Model	Control Mechanisms of material errors have been included in emission and removal calculations tools, i.e., sums of sampling points by forest type coincide with sample size ensuring no double counting in the sample-based activity data estimate.
Integration	Activity Data and Emission Factors are comparable. Carbon densities have been estimated according to the forest types, and non-forest land uses interpreted in the visual assessment.

12.2 Quantification of uncertainty in Reference Level Setting

Parameters and assumptions used in the Monte Carlo method

Parameter included in the model	Parameter values	Range or standard deviations		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
Deforestation and Degradation Emission Factors	The MC analysis included **13** Carbon density values for forest types and non-forest land uses categories considered in emission estimate. See all values in the Uncertainty calculation tool “Input_data&Models” Sheet – (cells F6..F19)	13%	205%	AGB estimation error, root : shoot ratio uncertainty.	Normal	Truncated Normal distribution (values > 0).
Removal factors	The MC analysis included **4** Removal factors. See all values in the Uncertainty calculation tool “Input_data&Models” Sheet cells F22, F24, F26 and F28	34%	75%	AGB removal factor estimation error.	Normal	Truncated Normal distribution (values > 0).
Deforestation Activity Data	**Forty-six** values for the Reference Period and **29** activity data for the Monitoring Periods were included in MC analysis. See all	16%	164%	Activity data estimation error	Normal	Truncated Normal distribution (values > 0).

	values in the Uncertainty calculation tool, "Input_data&Models" sheet, cells G32..G127 for Reference Period and cells G128..G223 for the Monitoring Periods.					
Activity Data for estimating inherited removals	The MC analysis included **32** Activity Data values for estimating inherited removals. See all values in the Uncertainty calculation tool "Input_data&Models" sheet, cells G228..G310.	12%	164%	Activity data estimation error	Normal	Truncated Normal distribution (values > 0).
Permanent Forest's Degradation	**Fifteen** values for the Reference Period and **7** activity data for the Monitoring Periods were included in MC analysis. See all values in the Uncertainty calculation tool, "Input_data&Models" sheet, cells G314..G377 for Reference Period and cells G378..G441 for the Monitoring Periods.	7%	164%	Activity data estimation error	Normal	Truncated Normal distribution (values > 0).

Quantification of the uncertainty of the estimate of the Reference level

		Deforestation	Forest degradation	Enhancement of carbon stocks
A	**Median**	**7,692,891**	**1,807,021**	**(126,306)**
B	**Upper bound 90% CI** (Percentile 0.95)	**9,336,641**	**2,533,692**	**(57,337)**
C	**Lower bound 90% CI** (Percentile 0.05)	**6,157,849**	**1,204,581**	**(235,682)**
D	**Half Width Confidence Interval at 90% (B – C / 2)**	**1,589,396**	**664,555**	**89,172**
E	**Relative margin (D / A)**	**21%**	**37%**	**-71%**
F	**Uncertainty discount**	**4%**	**8%**	**12%**

Sensitivity analysis and identification of areas of improvement of MRV system

See ER-MR Section 5.3.
The following table show each parameter's contribution to the Emissions Reduction's uncertainty. Three parameters represent 39% of total ER's uncertainty: i. Carbon Density of Dense Forest-ombrophile stratum (16.2%), ii. Removal Factor of Agro-foret-<20 yr (14.2%) and iii. Activity Data Deforestation 2020-2021 mesophile stratum Secondary Forest to Other crops conversion 8.5%).

Input Variable	Corresponding Input Value			Swing	Percent Swing^2
	Low Output	Base Case	High Output		

CD-11-Dense Forest-ombrophileDF	248.45	280.26	312.07	711,214	16.2%
RF-Agro-foret-<20 yr	-2.90	-11.59	-20.28	664,156	14.2%
AD-Defo_2020-2021_mesophile_SF-OC	5,448.11	2,060.20	(1,327.70)	514,170	8.5%
CD-50-Grassland-GG	84.23	39.88	-4.47	372,620	4.5%
AD-Defo_2020-2021_ombrophile_SF-OC	1,608.99	608.66	(391.67)	315,694	3.2%
AD-Defo_2000-2010_ombrophile_DF-CC	68,067.38	81,268.77	94,470.15	307,888	3.0%
CD-12-Secondary Forest-ombrophileSF	131.02	147.57	164.11	290,731	2.7%
CD-21-Cocoa-CC	50.27	45.40	40.53	267,480	2.3%
AD-Defo_2020-2021_ombrophile_SF-HH	1,608.99	608.66	(391.67)	256,478	2.1%
AD-Defo_2010-2015_ombrophile_DF-CC	20,834.15	28,788.64	36,743.12	180,239	1.0%
AD-Defo_2015-2020_ombrophile_DF-OC	12,441.20	6,385.04	328.88	168,196	0.9%
AD-Defo_2020-2021_mesophile_AF-OC	1,652.50	625.11	(402.28)	157,010	0.8%
AD-Defo_2000-2010_ombrophile_DF-OC	9,923.35	16,706.53	23,489.70	156,795	0.8%
AD-Defo_2020-2021_ombrophile_AF-OC	1,608.99	608.66	(391.67)	154,740	0.8%
CD-22-Perennial crops-PC	129.59	104.10	78.61	146,894	0.7%
AD-Defo_2010-2015_ombrophile_SF-CC	65,343.65	81,012.16	96,680.68	144,297	0.7%
AD-Defo_2015-2020_ombrophile_DF-GG	9,912.75	4,865.35	(182.05)	141,834	0.6%
AD-Defo_2015-2020_ombrophile_DF-CC	5,628.33	2,128.35	(1,371.64)	118,938	0.5%
AD-Defo_2015-2020_ombrophile_SF-CC	27,874.99	19,902.31	11,929.62	118,500	0.5%
CD-11-Dense Forest-mesophileDF	141.76	165.30	188.84	107,930	0.4%
AD-Defo_2015-2020_ombrophile_SF-OC	9,810.23	5,497.10	1,183.97	106,685	0.4%
AD-Defo_2015-2020_ombrophile_SF-GG	12,438.07	7,648.53	2,858.99	101,018	0.3%
AD-Defo_2020-2021_ombrophile_AF-HH	1,608.99	608.66	(391.67)	95,524	0.3%
CD-14-Agro-forest-AF	58.71	54.20	49.69	92,989	0.3%
AD-Defo_2020-2021_ombrophile_AF-CC	2,631.54	1,217.32	(196.91)	92,285	0.3%
CD-23-Other crops-OC	9.68	5.53	1.38	90,171	0.3%
AD-Defo_2015-2020_mesophile_SF-OC	8,520.22	4,560.64	601.06	88,431	0.3%
AD-ForestGain_2000-2010_mesophile_00_10-AF	3,873.45	1,753.20	(367.06)	87,988	0.2%
CD-60-Other lands-OL	84.23	39.88	-4.47	86,844	0.2%
AD-Defo_2020-2021_mesophile_AF-CC	1,652.50	625.11	(402.28)	86,419	0.2%
AD-Defo_2000-2010_ombrophile_SF-CC	45,580.78	58,148.89	70,717.00	86,004	0.2%
AD-Defo_2010-2015_ombrophile_DF-OC	3,799.87	8,039.35	12,278.83	85,694	0.2%
AD-Defo_2000-2010_ombrophile_SF-OC	18,384.32	27,333.00	36,281.68	84,417	0.2%
AD-Defo_2015-2020_mesophile_DF-CC	2,982.80	1,128.09	(726.62)	83,850	0.2%
AD-Defo_2015-2020_mesophile_SF-GG	9,638.46	4,745.52	(147.43)	82,744	0.2%
AD-Defo_2015-2020_ombrophile_AF-OC	9,323.79	5,171.64	1,019.49	82,663	0.2%
AD-Defo_2010-2015_mesophile_SF-PC	6,225.57	2,685.31	(854.94)	81,609	0.2%
AD-Defo_2000-2010_ombrophile_DF-GG	6,882.35	12,059.02	17,235.69	81,162	0.2%

AD-ForestGain_2000-2010_mesophile_00_10-SF	2,701.92	1,250.22	(201.48)	79,571	0.2%
AD-Defo_2015-2020_mesophile_SF-CC	10,389.91	6,631.94	2,873.97	78,768	0.2%
AD-Defo_2015-2020_mesophile_AF-OC	7,079.95	4,375.76	1,671.57	78,539	0.2%
AD-Defo_2015-2020_mesophile_DF-GG	1,652.50	625.11	(402.28)	78,378	0.2%
AD-Defo_2010-2015_ombrophile_AF-PC	1,608.99	608.66	(391.67)	77,547	0.2%
AD-Defo_2015-2020_ombrophile_AF-GG	10,619.45	5,474.01	328.56	75,150	0.2%
AD-Defo_2015-2020_mesophile_AF-CC	13,458.25	7,430.83	1,403.40	73,942	0.2%
AD-Defo_2015-2020_mesophile_SF-HH	1,652.50	625.11	(402.28)	73,338	0.2%
AD-Defo_2015-2020_ombrophile_AF-CC	8,558.95	5,236.99	1,915.03	72,549	0.2%
AD-Defo_2015-2020_mesophile_AF-GG	2,701.92	1,250.22	(201.48)	72,055	0.2%
AD-ForestGain_2000-2010_mesophile_Before 00-10-AF	132,870.22	113,286.57	93,702.93	70,838	0.2%
AD-ForestGain_2000-2010_mesophile_Before 00-10-SF	121,621.84	103,210.44	84,799.04	70,838	0.2%
AD-ForestGain_2010-2015_mesophile_Before 00-10-AF	122,340.51	103,344.21	84,347.91	70,838	0.2%
AD-ForestGain_2015-2020_mesophile_Before 00-10-AF	108,240.53	90,287.40	72,334.28	70,838	0.2%
AD-ForestGain_2020-2021_mesophile_Before 00-10-AF	107,591.55	89,662.29	71,733.04	70,838	0.2%
AD-ForestGain_2010-2015_mesophile_Before 00-10-SF	63,211.80	49,667.42	36,123.04	70,838	0.2%
AD-ForestGain_2015-2020_mesophile_Before 00-10-SF	50,880.67	38,352.71	25,824.76	70,838	0.2%
AD-ForestGain_2020-2021_mesophile_Before 00-10-SF	47,719.77	35,667.40	23,615.03	70,838	0.2%
AD-ForestGain_2010-2015_mesophile_10_15-AF	14,169.70	8,055.94	1,942.17	70,838	0.2%
AD-ForestGain_2010-2015_mesophile_10_15-SF	7,760.92	3,935.53	110.14	70,838	0.2%
CD-13-Forest plantations / reforestation-mesophilePP	417.43	241.44	65.45	70,838	0.2%
CD-13-Forest plantations / reforestation-ombrophilePP	417.43	241.44	65.45	70,838	0.2%