Forest Carbon Partnership Facility (FCPF)
Carbon Fund

ER Monitoring Report (ER-MR)

ER Program Name and Country:	Emission Reduction Program in Atiala Atsinanana (ERP-AA), Republic of Madagascar
Reporting Period covered in this report:	From 01/01/2023 to 31/12/2024
Number of FCPF ERs:	2,664,738
Quantity of ERs allocated to the Uncertainty Buffer:	504,685
Quantity of ERs to allocated to the Pooled Reversal Buffer:	1,036,287
Number of FCPF ERs from enhanced Removals through afforestation/reforestation (A/R)	0
Quantity of ERs to be cancelled from the uncertainty buffer to compensate for previous overestimations.	0
Date of Submission:	10-June-26
Version	6.4

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LIST OF ACRONYMS

AD	:	Activity Data
AGB	:	Above-ground biomass
BGB	:	Below-ground biomass
BNCCREDD+	:	National Office of Climate Change and REDD+
BSP	:	Benefit-Sharing Plan
CAS	:	Special Allocation Account
CAZ	:	Ankeniheny-Zahamena Corridor
CDPs	:	Communal Development Plans
CEF	:	Forest Cantonment
CI	:	Conservation International
COBA	:	Community-Based
COSAP	:	Orientation and Monitoring Commitee of the Protected Area
DD	:	Deforestation and Forest Degradation
DGGE	:	Directorate General of Environmental Governance
DAPRNE		**Directorate of Protected Areas, Renewable Natural Resources, and Ecosystems**
DCSI		**Directorate of Communication and Information System**
DNA		Designated National Authority
DRAE	:	Regional Directorate of the Agriculture and Livestock
DREDD	:	Regional Directorate of the Environment and Sustainable Development
DRGPF	:	Directorate of the Reforestation and the Forest Landscape Management
DRMCF	:	Decree on the regulation of access to the forest carbon market
EF	:	Emission Factors
EO	:	Earth Observation
ER	:	Emission Reduction
ERP	:	Emission Reduction Program
ERPAA	:	Emission Reduction Program "Atiala Atsinanana"
ERPD	:	Emission Reduction Program Document
ESMF	:	Environmental and Social Management Framework
FCPF	:	Forest Carbon Partnership Facility
FF	:	Functional Framework
FMS	:	Forest Monitoring System
FREL	:	Forests Reference Emission Levels
GFOI	:	Global Forest Observations Initiative
GFW	:	Global Forest Watch
GHG	:	GreenHouse Gas
IPCC	:	Intergovernmental Panel on Climate Change
LOFM	:	Forest Observation Laboratory in Madagascar
LULUCF	:	Land Use, Land Use Change and Forestry
MINAE	:	Ministry of the Agriculture and Livestock
MECIE	:	Compatibility of Investments with the Environment

MEDD	:	Ministry of the Environment and Sustainable Development
MEF	:	Ministry of Economy and Finances
MGD		Methods and Guidance Documentation
MGP	:	Complaint Management Mechanism
MMR		Monitoring, Measuring and Reporting
MNP	:	Madagascar National Parks
MRV	:	Measurement, Reporting, and Verification MNV : Mesure, Notification, Verification
OSC	:	Civil Society Organization
PA	:	Protected Area
PAP	:	People Affected by the Project
PERR-FH	:	Eco-Regional REDD Program in Humid Forests
PLOF	:	Local Plan for Land Occupation
PLUT	:	Utilization Plan
QA/QC	:	Quality assurance/quality control
REDD+	:	Reducing Emissions from Deforestation and Forest Degradation
RL	:	Reference Levels
SIIP	:	REDD + Initiatives and Programs Information System
SIS	:	Safeguards Information System
SOPs	:	Standard Operating Procedures
TEC	:	Technical Evaluation Committee
TGRN	:	Management Transfer of natural resources
UNFCCC		United Nations Framework Convention on Climate Change
UOT	:	Land Use and Occupation
VOI	:	Vondron'olona Ifotony
WCS	:	Wildlife Conservation Society
WWF	:	World Wildlife Fund

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

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

Progress on the actions and interventions under the ER Program

Compared with the situation during the 2021 2022 period, the implementation period was marked by the disbursement of the first carbon payment benefits to beneficiaries at the field level. Indeed, starting from July 2024, the Program was finally able to operationalize on the ground the financing derived from the distribution of benefits from the first carbon payment.

The program's activities during the 2023-2024 period were financed partly by the fund from the first payment and partly by investments made by the program's stakeholders:

- In areas outside initiatives: through the minimum control carried out by the Forestry Administration (Regional Direction and cantons in charge of Forests).
- At the level of the 15 REDD+ initiatives: through investments by initiative promoters in (i) monitoring and surveillance, (ii) implementation of alternatives to deforestation by improving livelihoods for communities, and (iii) social activities that benefit communities.

Activity reports for each initiative are available under the link: https://drive.google.com/drive/folders/1CyfiwClSibZffiu5UWpLi6Pp8DUcxkuf?usp=sharing

As this ERs Report covers the final reporting period under the ERPA, it is important to note that, in 2025, Madagascar adopted a revised regulatory framework governing access to the forest carbon market through an amendment to Decree No. 2021-113. This reform introduced important adjustments to the REDD+ Benefit Sharing Plan as well as to the associated financial management mechanism.

Accordingly, the payments related to both the current 2023–2024 reporting period and the preceding 2021–2022 period will be implemented under these updated regulatory and institutional arrangements.

Details of activities implemented:

Generic activities : Generic protected area management activities included forest patrols and surveillance, mixed brigade operations, fire control activities, ecological monitoring, environmental awareness and sensitization campaigns, and strengthening of community-based natural resource management structures (VOI/COBA).	Under the 14 REDD+ initiatives

Strengthening local governance: support and capacity building for the PA Steering Committee (COS and COSAP)	Under the 14 REDD+ initiatives

Strengthening transferring natural resource management to communities (TGRN): Evaluation and renewal of TGRN community contracts, formalization of community agreements (DINA)	Under the COMATSA PA : 49 forest communities (VOI) Under the Makira PA : 80 VOI + 4 nouveaux VOI Under the CAZ PA : 53 VOI


Monitoring and surveillance: community patrols and control missions with forces	**24,757 patrol missions** : Ambatovaky (1,120 patrols), Analamazaotra (402 patrols), Anjanaharibe-Sud (1,032 patrols), Betampona (240 patrols), Makira (413 patrols), Mananara Nord (1,073 patrols), Mangerivola (328 patrols), Mantadia (443 patrols), Marojejy (2,607 patrols), Marotandrano (185 patrols), Masoala (14,483 patrols), CAZ (800 patrols), and Zahamena (1,631 patrols).

Restoration/Reforestation	A total of **944.05 ha of active restoration** and **720.4 ha of passive restoration** were implemented during the reporting period.

Ecological monitoring for conservation target species	Under the 14 REDD+ initiatives

Implementation of Information, Awareness and Education Programs	A total of **244 community awareness and environmental education sessions in schools** were conducted, reaching **17,473 people** during the reporting period.

Alternatives to deforestation and income-generating activities	the activities reached a total of at least **2,258 beneficiaries**, including: • **1,116 women** • **1,142 men** • **296 households** The livelihood support activities and interventions implemented are detailed as follows: • Promotion of improved agricultural practices benefiting **320 people** (**89 women and 231 men**); • Poultry farming support benefiting **238 people** (**96 women and 142 men**); • Fish farming support benefiting **108 people** (**23 women and 85 men**); • Sheep farming support benefiting **367 people** (**197 women and 170 men**); • Permaculture activities benefiting **83 people** (**20 women and 63 men**); • Beekeeping support benefiting **81 people** (**20 women and 61 men**); • Rehabilitation of agricultural dams; • Construction of **2 micro hydro-agricultural dams**; • Implementation of **1 village lodge rehabilitation microproject** for ecotourism; • Establishment of a new partnership with FOFIFA for the cocoa value chain, including provision of inputs and training; • Support to vegetable farming activities; • Rehabilitation and maintenance of ecotourism infrastructure, including **8 km of ecotourism trails** and **1 footbridge**; • Provision of agricultural production equipment and training (wheelbarrows, shovels, rakes, watering cans) for community associations; • Construction of an agricultural irrigation structure; • Agroforestry activities involving the distribution of **1,170 fruit tree seedlings** and **130 cash crop seedlings**; • Support to **619 beneficiaries** through the distribution of **21,916 clove tree seedlings**; **296 beneficiaries of coffee trees** • Support to **1 beneficiary** through the distribution of **45 Ravintsara seedlings**.






Value chain and market promotion	The establishment of a new conservation enterprise in MaMaBay (ECM) for cocoa production, through a partnership with Alba Chocolat, aimed at supporting sustainable cocoa value chain development and improving market opportunities for local communities.

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

Monitoring during the 2021 2022 period showed that there were no leaks around the Program area. Analyses of displacement pressures remain relatively unchanged for the 2023-2024 period.

When we look closely at the potential leakage zone, which has been set at 10km around the Program, we have identified the potential leakage areas as follows:

- COMATSA, an area managed by WWF, the southern part of which is within the Program boundary, but the northern part is outside the boundary.
- AP Mahimborondrro, an area managed by TPF, part of which is within the Program boundary, but part of which is outside the boundary.
- AP Marotandrano, area managed by MNP, part of which is within the Program boundary, but part of which is outside the boundary.
- AP Tsaratanàna, area managed by MNP, part of which falls within the potential leakage zone.

The activities carried out in potential displacement zones are maintained by the managers of the protected areas so that there is no displacement either between areas within the Program or towards areas surrounding the Program. The areas were part of Marotandrano, Mahimborondo and COMATSA which is outside the Program boundaries, as well as Bemanevika, Tsaratanàna and Anjozorobe Angovo.
The activities in areas concerning the COMATSA, Mahimborondro and Marotandrano PAs have already been documented in the activities reported above. As a reminder, the activities are related to the maintenance of the PA's physical boundaries and to forest monitoring and surveillance: patrols and control of forest fires.

Effectiveness of the organizational arrangements and involvement of partner agencies

The ER Atiala Atsinanana Program is coordinated by the National Office in charge of REDD+ and its regional coordinators. All Program structures across the five regions have been in place since 2020 and have progressively been strengthened in terms of equipment and capacity in order to enable the delegation of part of the Program management responsibilities to the implementing regions.

During the 2023–2024 reporting period, a major milestone of the Program was the effective rollout of the first carbon payments on the ground for the benefit of implementation actors and local structures involved in REDD+ activities. This marked an important step toward operationalizing part of the carbon benefit-sharing mechanisms established under the Program.

In this context, capacity-building activities mainly focused on carbon revenue planning and management, as well as on monitoring, reporting, and management systems for REDD+ activities at both initiative and local governance structure levels.

With regard to the operational management of REDD+ activities, the initiative promoters ensure the supervision and technical and financial support of field actors in the implementation of intra-initiative activities, as well as the monitoring and reporting of REDD+ implementation activities. As these responsibilities are already well established within the forestry administration framework, no major difficulties were encountered in operationalizing the institutional arrangements.

As part of the Program’s progressive strengthening, future orientations will focus more specifically on areas outside the existing Program initiatives in order to further support actors operating in small protected areas and “orphan” VOI-managed TGRN areas that currently receive limited structured support.

Updates on the assumptions in the financial plan and any changes in circumstances that positively or negatively affect the financial plan and the implementation of the ER Program

The 2023–2024 period was marked by the receipt of the first REDD+ results-based payment of USD 8.8 million. Disbursed during the last quarter of 2023, this payment was redistributed to beneficiaries through the established benefit-sharing mechanisms, providing additional financial resources to support the implementation of the ER Program.

This contribution was particularly important given the financing context of Madagascar’s protected areas. Protected area management is largely supported through project-based funding provided by technical and financial partners. While these funding sources are essential, they are generally time-bound, subject to successive funding cycles, and often insufficient to fully address the long-term needs associated with conservation, protected area management, and the development of sustainable livelihoods for local communities.

Against this backdrop, the REDD+ payment generated significant financial additionality. In protected areas with more established management systems, it enabled the scaling up of existing activities, particularly by expanding economic alternatives and livelihood opportunities for local communities. In the CAZ landscape, the REDD+ payment was especially critical, as it ensured the continuity of field interventions following the closure of previous funding sources. In this context, REDD+ revenues became the main source of financing available to sustain ongoing activities while additional funding was being mobilized.

Beyond supporting program implementation, the REDD+ payment strengthened the financial resilience of beneficiary protected areas and enhanced their ability to sustain long-term efforts in emission reductions, forest conservation, and the improvement of local livelihoods.

1.2 Update on major drivers and lessons learned

A data collection was conducted with the forestry administration and the REDD+ initiative responsible in the ER Program Atiala Atsinanana including the five (05) Regions of the Program during the Year 2026. The objective of the survey that was done online (because of the lack of time for doing field surveys in order to conduct the data collection) was mainly to collect data to determine the evolution of the causes of the loss of forest cover during the reporting period. The synthesis of the results of the survey are seen in the next table. We can note that the survey was based on : interviews and focus group meetings that took place in March 2026.

Table 1: Drivers of deforestation and forest degradation in the Atiala Atsinanana Emissions Reduction Program area for the 2023-2024 monitoring period

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
Transport infrastructure and accessibility	For the monitoring year 2020, it seems that the districts are more deforested when their forests are poorly accessible. The general low accessibility of forests can in fact concentrate pressure (harvesting activities, slash-and-burn cultivation, etc.) on the few more accessible forest areas.	For the monitoring years 2021 and 2022, the difficulty of access and the poor condition of the roads still tends to concentrate pressure on the forest. In addition to this, monitoring or control and patrols are more difficult, and little or not carried out when the area to be examined is difficult to access (road conditions, rugged terrain, etc.) The low accessibility of forests often concentrates pressures in remote and/or very localized areas. Thus, the trend remains the same as for 2020 for this driver. In fact, Districts are always more deforested when their forests are difficult to access. The examples of Sofia and SAVA, in the Districts of Bealanana (e.g.: COMATSA Initiative) and Andapa (e.g.: Marojejy Initiative) respectively, are a perfect example to illustrate the phenomenon. For the Analanjirofo Region, in the Districts	For 2023-2024 the transport, infrastructure and accessibility conditions remains the same as for previous reporting periods.	Alaotra Mangoro Example: For Zahamena, the situation remains the same

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
		of Soanierana Ivongo and Vavatenina, accessibility remains very difficult. The forest areas of the Initiatives are often located far from the capital of the municipality. However, clearing is concentrated in the regions surrounding the Parks, in and on the interior border of the Initiatives (Initiative buffer zone). The phenomenon is also valid for the Alaotra Mangoro and Atsinanana regions because accessibility to the forest areas is low, which leads to exploitation in the parts closer to the villages surrounding the Parks, in and on the inner edge of the Initiatives (buffer zone initiatives).		
Mines	In 2020, mining was classified as a significant driver of deforestation and/or forest degradation.	In 2021 and 2022, the assessment remains the same because mining is omnipresent in the Initiatives sites. Often illegal and sometimes regulated (presence of mining tiles inside the Protected Area), and having a more or less serious impact on the forests. The cases of Makira and Anjanaharibe Sud in the SAVA Region are an example of this phenomenon. The	For the actual monitoring period, the mining is still a significant driver of deforestation and/or forest degradation.	Analanjirofo, SAVA, Sofia, Alaotra Mangoro, Atsinanana Examples: In Analanjirofo Region, gold mining by migrants, as in the case of Ambatovaky, constitutes a direct driver of deforestation. In the SAVA Region, more specifically in the Anjanaharibe Sud initiative, the presence of mining constitutes a direct cause of deforestation.

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
		Alaotra Mangoro Region is also concerned.		In the COMATSA initiative, SAVA and Sofia region ; mining of precious stone constitutes a driver of deforestation. In the Analanjirofo region, for Masoala and Makira initiatives, mining is a direct cause of deforestation. Also, mining is still a deforestation driver, for CAZ, Zahamena, Analamazaotra Mantadia, Mangerivola, Betampona initiatives
Permanent crops	As results for the study on 2021, permanent crops are responsible for forest degradation: culture of rice, clove, … It is also a way to land grabbing. These cases were confirmed, as an example is the District of Maroantsetra.	In 2021 and 2022, permanent crops are still a significant driver of Deforestation and Degradation. As example, the case of vanilla crops in SAVA, around Protected Areas. Farmers cleared forests to set up their plantations with vanilla, which was one of the most prized commodities and sold at a high price. Despite the drop in the price of vanilla in 2021, the population continues to expand cultivation hoping for a reversal of the price trend. In Analanjirofo, the permanent cultivation of vanilla is practiced, promoting	The situation remains the same for this direct cause of deforestation and degradation on 2023-2024	SAVA, Sofia, Alaotra Mangoro, Atsinanana Examples: In the COMATSA initiative, SAVA and Sofia region; vanilla cultivation is a driver of deforestation and degradation. In the SAVA region, in the case of the Marojejy initiative, undergrowth vanilla cultivation constitutes a factor of deforestation. Mining continues to be a major driver of deforestation within the CAZ, Zahamena, and Analamazaotra Mantadia ; Mangerivola ; Betampona initiatives, Alaotra

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3)* ***(Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing***
		deforestation and forest degradation. Crops requiring shade to improve product quality; forests are destroyed to the detriment of culture. In the Atsinanana Region in general, permanent crops is one of the primary drivers of forest degradation. For the Alaotra Mangoro Region, permanent cultivation is not classified as a driver of Deforestation and Degradation. It has a negligible impact in the Sofia Region.		Mangoro and Atsinanana Regions.
Annual crops	This practice was a main cause of deforestation noted in the Alaotra Mangoro, Analanjirofo, Atsinanana Regions. It is most often done through the practice of clearing or "tavy".	Clearing for rice cultivation is one of the causes of deforestation, the population is extending cultivation areas on the "tanety" or the hillsides to increase production despite the presence of a relatively large area of lowlands allowing this cultivation. The absence of a hydro-agricultural dam is	Annual crops are still a main cause of deforestation for 2023-2024 monitoring period.	Sofia, SAVA, Analanjirofo, Alaotra Mangoro, Atsinanana Examples: The presence of tavy for rice cultivation is noted in the Ambatovaky initiative, Analanjirofo region. In the SAVA Region, as seen in the case of the Anjanaharibe Sud initiative, it is also noted that the use of tavy and slash-and-burn farming for bean cultivation is a direct cause of deforestation In the COMATSA initiative in the SAVA and Sofia regions, land

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
				clearing for rice cultivation is a direct cause of deforestation In the Analanjirofo region, as part of the Mananara Nord initiative, the practice of tavy for agricultural expansion and land grabbing are driving to deforestation In the SAVA region, as seen in the Marojejy initiative, the traditional practice of tavy for annual crops is a factor contributing to deforestation In the Analanjirofo region, as seen in the Masoala initiative, the practice of slash-and-burn farming (tavy) for annual crops is a direct cause of deforestation -In the Analanjirofo Region, as seen in the case of the Makira initiative, the practice of tavy for annual crops is a direct cause of deforestation Annual cropping continues to be a driver of deforestation and degradation during the third monitoring period for the CAZ, Zahamena, Analamazaotra Mantadia, Mangerivola, and Betampona initiatives.

Type of Driver	***Results of LOFM studies (data collection on 2021 for MNV 1)***	***Results of LOFM studies (data collection on 2023 for MNV 2)***	***Results of LOFM studies (data collection on 2026 for MNV 3)***	***Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing***
Livestock	In 2020, livestock farming is not classified as a factor or driver of deforestation or degradation in the PRE AA-Program area.	In 2021 and 2022, livestock farming is not identified as a driver of deforestation or degradation. According to the interviews/data collection and observations carried out, livestock farming has very little impact on forests and the risks are rather grazing fires in the Sofia region. In the SAVA Region, livestock farming has no direct impact or influence on the pressure on the forest. For Analanjirofo and Atsinanana, breeding also certainly has no effect. Thus, livestock farming cannot be listed as a driver of deforestation or degradation.	In 2023-2024, livestock farming is still not classified as a factor or driver of deforestation or degradation in the PRE AA-Program area	N/A
Commercial timber exploitation	In 2020, timber trafficking, commercial logging - whether legal or not - are among the important direct causes of deforestation on both a small and large scale. The marketing of wood plays a more or less important role, among other things. Timber exploitation was always counted as deforestation	In 2021 and 2022, the commercial exploitation of wood still plays a preponderant role given that there are samples or cuts in lots where the wood is intended to be marketed (timber, construction wood). This is occurring in particular in the Alaotra Mangoro and Analanjirofo Region, but there is also illicit trafficking in certain areas such as in the SAVA Region where selective	Commercial timber exploitation is for 2023-2024 among the important direct causes of deforestation (small and large scale).	Sofia, SAVA, Analanjirofo, Alaotra Mangoro Examples: In the Sofia region, as part of the Mahimborondro initiative, the illegal logging of timber for commercial purposes is a cause of deforestation In the SAVA region, as exemplified by the Marojejy initiative, the illegal logging of precious woods for commercial purposes is a major cause of

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
	logging harms the forest (more or less significant degradation). This traffic still exists mainly because of corruption. There is also exploitation in the Atsinanana Region, and the Sofia region but lesser.			deforestation In the Analanjirofo region, as seen in the Masoala initiative, the illegal logging of timber for commercial purposes is a major cause of deforestation Commercial timber exploitation continues to be a driver of deforestation and degradation within the Analamazaotra Mantadia initiative
Exploitation of non- marketed fuelwood and service wood	In 2020, as in previous years (reference level), the exploitation of non- marketed fuelwood and service wood does not constitute a driver of deforestation or degradation.	In 2021 and 2022, there is exploitation of unmarketed firewood and service wood in the Program area, but which is still of a low volume, and which sometimes concerns only dead wood. Overall, it is not a driver of Deforestation or Degradation.	The exploitation of non- marketed fuelwood and service wood does not constitute a driver of deforestation or degradation for 2023-2024	N/A
Carbonization	In 2020, coal mining was a direct cause of Deforestation and Degradation	In 2021 and 2022, this type of driver still constitutes an important factor in Deforestation and Degradation due to the practices carried out in the Sofia Region (e.g. in the Bealanana District, coal mining is widely practiced) and in the Atsinanana Region in one hand. On the other hand, in	Carbonization is still an important factor of Deforestation and Degradation in 2023-2024	SAVA, Sofia, Analanjirofo, Alaotra Mangoro, Analanjirofo Examples: In the SAVA and Sofia regions, as exemplified by the COMATSA initiative, coal mining is a major driver of deforestation In the Analanjirofo region, as exemplified by the Masoala initiative, coal mining is a major driver of deforestation

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
		the SAVA Region (e.g. the case of the Andapa District), coal mining is not one of the direct causes of Deforestation and Degradation because it is almost not practiced on 2021 and 2022. Carbonization is also not a driver of Deforestation and Degradation in the Analanjirofo Region where the population instead uses dead wood.		For the Analamazaotra Mantadia (eastern part), CAZ, and Zahamena initiatives, charcoal production remains a driver of deforestation and degradation during this third monitoring period
Fires	For the year 2020, fires were listed as a major factor generating Deforestation and Forest Degradation.	In 2021 and 2022, the Analanjirofo Region is not affected by this type of factor and for the Sofia Region the impact on forests is less because the fire-fighting around Protected Areas are generally effective according to the interviews carried out. In the SAVA Region, cleaning-up fires constitute a small-scale cause of deforestation and degradation. For the Atsinanana and Alaotra Mangoro Regions, fires are also an omnipresent phenomenon which destroy and degrade forests. Overall, fires continue to be a significant driver of Deforestation and	For the years 2023-2024, fire is still listed as a major factor generating Deforestation and Forest Degradation.	SAVA, Sofia, Analanjirofo, Alaotra Mangoro, Atsinanana Examples: In the Analanjirofo region, as in the case of the Ambatovaky Initiative, the occurrence of uncontrolled fires between the buffer zones and the park boundaries is a direct cause of deforestation. For Masoala, fires in coastal areas are a major driver of deforestation. In the SAVA and Sofia regions, as seen in the case of the Anjanaharibe Sud initiative, COMATSA and Mahimborondro initiatives; agricultural fires caused by coal mining and, savanna fires affecting the forest edges are causing deforestation. Another example is for Analamazaotra Mantadia , CAZ, Zahamena, and Betampona

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
		Degradation.		initiatives where land clearing followed by burning is one of the main causes of deforestation and degradation in the Alaotra Mangoro and Atsinanana regions.
Demography	Migration phenomena generated significant deforestation because migrants resort to illegal artisanal mining, the practice of tavy, and illegal logging.	Demographic growth and migration promote deforestation and degradation through the grabbing of fertile land for crops, illegal (artisanal) mining and penetration into conserved forests for illegal cutting and harvesting of wood. It is a major driver of Deforestation and Degradation.	Concerning the demography, the situation remains the same for the period 2023-2024.	Alaotra Mangoro, Atsinanana Examples: Population growth and migration remain major drivers of deforestation and degradation during this third monitoring period in the Atsinanana and Alaotra Mangoro regions, particularly within the CAZ, Zahamena, Analamazaotra Mantadia, Betampona, and Mangerivola initiatives.
Economic context	In 2020, the isolation and low education of the population would be partly responsible for deforestation and forest degradation.	For the years 2021 and 2022, Deforestation in the SAVA region is closely linked to the drop in the price of vanilla. Indeed, the more the price of vanilla falls, the more the local population concentrates on vanilla cultivation and rice farming in order to produce more. Through this, they are deforesting more forest land. For Analanjirofo, poverty encourages people to exploit forest land for the cultivation of rice and cloves.	The economic context as described for 2020-2021-2022 has also an impact on deforestation and degradation on 2023-2024	Alaotra Mangoro, Atsinanana Example: In 2023 and 2024, poverty and lack of income remain underlying causes of deforestation and degradation within the CAZ, Zahamena, Analamazaotra Mantadia, Betampona, and Mangerivola initiatives.

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
		The economic context greatly influences land use, and therefore increases deforestation.		
Technology	For the monitoring year 2020, we noted that the technology was brought to village communities but the monitoring of these agricultural development projects which aimed to improve the standard of living of the population was non- existent. Added to this is the lack of knowledge of household cash management and the lack of will to adopt better behavior with regard to production (techniques, improved seeds, cash management, etc.) which generated constant pressure on forest resources, through the expansion of crops, stagnant yield, and poor	During the period 2021 and 2022, the installation of development projects promoted the improvement of the techniques used by farmers. But the sustainability of achievements always depends on the availability of financing and aid. For SAVA, despite technological innovations, cultural practices remain the same, those consisting of exploiting fertile land, carrying out an unconsidered grabbing of land for cultivation and making tavy. As for Analanjirofo, the fact reported is that the lack of irrigation infrastructure on the plains leading to poor production or insufficient production or the impossibility of lowland development causes the practice of clearing for the benefit of rice	The lack of technology adoption is still a cause of deforestation and degradation for 2023-2024.	Sofia Example: The lack of technology, as the agricultural intensification and adoption of modern technology is one of the direct cause of deforestation in the Sofia Region. This can conduct people to destroy the forests (ex: tavy).

Type of Driver	*Results of LOFM studies (data collection on 2021 for MNV 1)*	*Results of LOFM studies (data collection on 2023 for MNV 2)*	*Results of LOFM studies (data collection on 2026 for MNV 3)*	*Examples of the regions concerned in the Program (data collection on 2026 for MNV 3) (Reports and interview results seen in: https://drive.google.com/file/d/1eZsmr0HbNMindQrvwlJ6Yq2CH41CfT5F/view?usp=sharing*
	performance.	cultivation.		

In general, there was no change within the direct causes of deforestation and degradation for the Program in the five Regions (Alaotra Mangoro, Atsinanana, Analanjirofo, Sofia, SAVA).

For the indirect causes of deforestation that were identified for the ERPD, the first reporting period (2020), second reporting period (2021-2022) and actual reporting period (2023-2024); they were:

- Demography and migration:

According to the ERPD, tavy traditionally takes place in secondary forests, but limited availability of land, population growth and migration can lead to an increase of tavy in primary forests. Migration may be due to the opening of illegal artisanal mines, illegal logging, and search for fertile lands, or agricultural opportunities in cash crops. Migration is a cultural tendency fostered by the lack of clear land tenure and land legislation. The density and distribution of the population were recognized as explanatory variables for deforestation. The saturation of irrigated valleys pushes the youngest and the landless people to forest areas.
For the year 2020, demography and migration remain underlying causes of deforestation of the forests in the ERP AA.
For 2023 and 2024 as for 2021 and 2022, migration was still remaining as a very important underlying cause as stressed by the experts that were interviewed.

- Economic Factors:

In the ERPD, it is said that the structural poverty among rural populations is a major underlying driving force behind deforestation, as rural populations are dependent on natural resources for their subsistence and local economy. But the lack of financial resources inhibits them from investing in sustainable practices. The social conditions in the ER-P area are described as a widespread poverty, a lack of economic opportunity, and reliance on tavy for basic subsistence.
Three types of markets are known to foster deforestation and degradation in the ER-P area:

- Agricultural products dedicated to export (e.g: vanilla, cloves and coffee;
- Precious wood;
- Mining and rare earth products.

As for 2020, 2021 and 2022, the situation remains the same during the monitoring period 2023 and 2024.

- Technological factors:

The ERPD explains that the agricultural intensification practices are currently too infrequently implemented to play a role in reducing deforestation. Meanwhile, the productivity of traditional agriculture systems (tavy) is stagnating or even declining and intensification practices are not widely observed. Thus, it can be considered that the lack of technological advances in the agricultural sector contributes to deforestation in all areas of the ER-P. Populations rely on slash-and-burn to increase fertility of soils. This situation is still remaining the same for 2023 and 2024.

- Policies and Institutional Factors:

Policies and institutional factors were listed as underlying cause of deforestation in the ER-P zone. The ERPD precises that the limited human and financial resources, the absence of a formalized arrangement for management between NGOs who work intensively in forest areas, and Madagascar National Parks, corruption, conflicts of interest, and the difficult implementation of the system for granting tender-based logging permits all contribute to weak forest governance, particularly at local levels.
This situation was still remaining in 2023 and 2024.

- Property and land tenure legislation:

In the eastern humid forest ecoregion, as the ERPD mentions and according to the interviews for the monitoring period, the traditional land tenure systems have undergone major changes over the last decade. The loss of power of village and traditional leaders, the rise of land transactions, the creation of local tenure offices (BIF) and the introduction of land certificates have altered the traditional land tenure systems. Customary tenure rules that often do not apply to forests now coexist with the current state law.
In 2023 and 2024, the problem of property and land tenure legislation is still undergoing and the impact is land grabbing, even inside the forests or Protected areas; the dilapidation of the natural resources such as precious stones, precious wood, fertile lands. Forest areas are shrinking in many areas.

- Culture:

The ERPD mentions that culture is an underlying cause of deforestation. Rural populations perceive the forest primarily as a reserve of arable land or pasture. Further surveys indicate that most households are aware of the benefits of reducing deforestation If intact or relatively intact forests are deforested, it seems that this is sometimes done "reluctantly".
Even though individual behavior can sometimes explain deforestation (no respect for protected areas, resistance to change, individualistic attitude) (Salva Terra, 2017). Discontent with local or central governments may also have some explanatory power for the starting of fires. It has also been mentioned that competition over land between ethnic groups linked with migratory phenomena explains some races for land clearing.

Finally, sacred forests and taboos provide protection to forests, but the concerned areas are too small to have a tangible impact and immigrants may be less prone to heed the established local belief systems.
The situation was the same during the monitoring period: 2023 and 2024.

- Environmental Suitability:

For 2023-2024, we can say that the localization of deforestation is still correlated with several physical variables: altitude, slope, soil fertility and forest fragmentation.

- Altitude: estimates of the most affected areas by deforestation among eastern rainforests vary between 400 and 1,000 m, mostly because the majority of low land forest has already disappeared (Salva Terra 2017).
- Slope: local communities practice tavy on slopes less than 40°.
- Soil fertility: although fertile soils are deforested first, the expansion of the frontier region is slower.
- Forest fragmentation: isolated forest patches are most likely to be deforested.

The areas that farmers target can be described in descending order of priority for cultivation by ease and productivity (high priority first)—the plains or shallows, valleys and then hills.

The criteria for choosing the land to be cleared are, in descending order—soil fertility, the absence of weeds and the presence of water (Salva Terra 2017).

The indirect causes of deforestation and degradation are the same.

1.3 Methodological deviations

No methodological deviation was found for this third reporting period. All the previous errors were corrected in the second monitoring report (years 2021-2022).

A few errors were found in the reference level validated during the preparation of the second monitoring report. These errors concern the incorrect integration of emission factors in the Excel file for emission factors relating to AGB for secondary forests, agroforestry and plantations; in addition the change in the parameter D in the calculation of emissions due to SOC which is the Time Dependence of Stock Variation Factors - default period for transition between equilibrium SOC values, in years.

- The first error is due to a mistake when copying the **above-ground biomass values** for secondary forests, agroforestry and plantations from the biomass sheet to the reference level calculation sheet (when the first monitoring report was drawn up). Secondary forest: value copied 46.2 false instead of 91.1 true; agroforestry: value copied 35.5 false instead of 87.9 true; plantation: value copied 91.1 false instead of 29.6 true.

- The second error concerns the copying of the plantation **root/shoot ratio value** from the biomass sheet to the reference level calculation sheet: copied value 1.0 false instead of 3.24 true.

- The third error concerns the change to the parameter D = 20 in the emissions calculation due to the **SOC** described above. In the ERPD it was assumed that D=1 which mean that emissions from SOC would occur instantaneously; this was done for the purpose of simplifying the calculations, yet this was not accurate. In order to make the calculations more accurate the D was changed to 20 years, in line with the IPCC guidelines. However, this would require the consideration of legacy emissions from one year to the following year, i.e. deforestation in year 1, would cause emissions in year 1 and in the following 19 years. Therefore, calculations were revised to consider these legacy emissions.

- The fourth error concerns the **program area**. The value of the program area of 6,980,308.19 hectares reported in the previous monitoring report was wrong. The correct program area is 6,913,969 ha. This area was derived from the following shapefile: https://drive.google.com/file/d/13Uc9Y0B4W1ou3Etv-eEUDdxsw2mX72zu/view?usp=sharing : delimitation of the Program ERP AA. This shapefile has always existed but unfortunately its correct area was not referenced or used for the estimates presented in the 1st monitoring report. As such, all estimates, including those for the reference level were updated to reflect the correct program area. The use of the correct program area has been approved by the FMT.

This has an impact on the estimation of the reference level and emission reductions in the first and the second reporting period.

The corrected reference level value will be found in Table 4, Section 4.1.

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

2.1 Forest Monitoring System

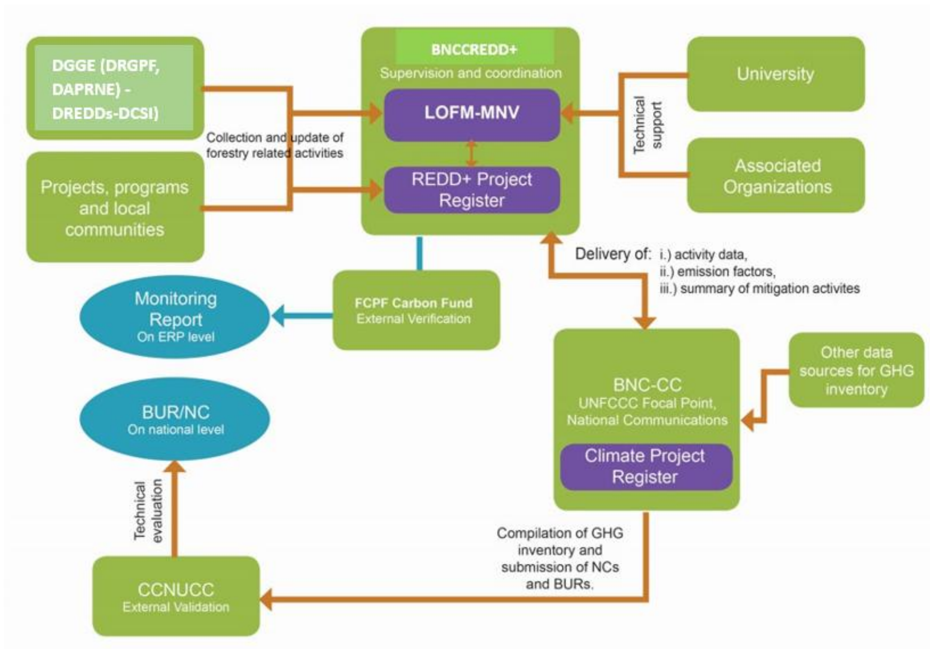
Table 2 : Forest monitoring system

Themes		State of play
Organizational structure, responsibilities, skills		The Government of Madagascar has established a National Forest Monitoring System (NFMS) that also performs the monitoring and reporting functions of the country's ER program for future emissions and potential emission reductions. The monitoring system is based on the following key elements: ▪ BNCCREDD+ (National Office of Climate Change and REDD+) is a Direction at the Ministry in charge of Environment and Forest. This national office coordinates climate changes and the Reduction of the Emissions from Deforestation and Forest Degradation (BNCCREDD+). This structure is responsible for supporting the coordination of its initiatives and actions relating to climate change and the Emission Reduction mechanism hees to Deforestation and Forest Degradation (REDD+). These actions aim to support: the promotion of a restful economy adapted to the effects of climatic changes; the promotion of sustainable development with low carbon emissions and other greenhouse gases emissions (GHG) causing climate change; the reduction of emissions linked to deforestation and the degradation of forests by the promotion of the REDD+ mechanism. The activities of the National Office aim to the development of the sale of carbon and the guarantee of the fair sharing of benefits, as well as the promotion of sustainable financing mechanisms to combat against climate change. The BNCCREDD+ assumes overall responsibility for future land use change assessment and ERP monitoring report development. *There are two (02) Divisions within BNCCREDD+ namely the Madagascar Forest Observation Laboratory (LOFM or "Laboratoire d'Observation des Forêts de Madagascar") and Methodology. The two Divisions each have distinct roles and responsibilities, as follows **Methodology Division** **<u>Roles and responsibilities</u>** - Design, implement and ensure the realization of national forest inventory methodologies - Ensure the implementation of Greenhouse gas inventories for the forestry sector - Establish the calculation methods of the Forests Reference Emission Levels (FREL) and proceed to their evaluation - Establish the methodological standards for the determination of Emission Factors and make the calculations - Ensure the measurement of carbon performance at the scale of REDD+ Programs and Initiatives - Participate in the calculation and reporting of carbon performance based on a transparent and reliable methodological process in coordination with the LOFM

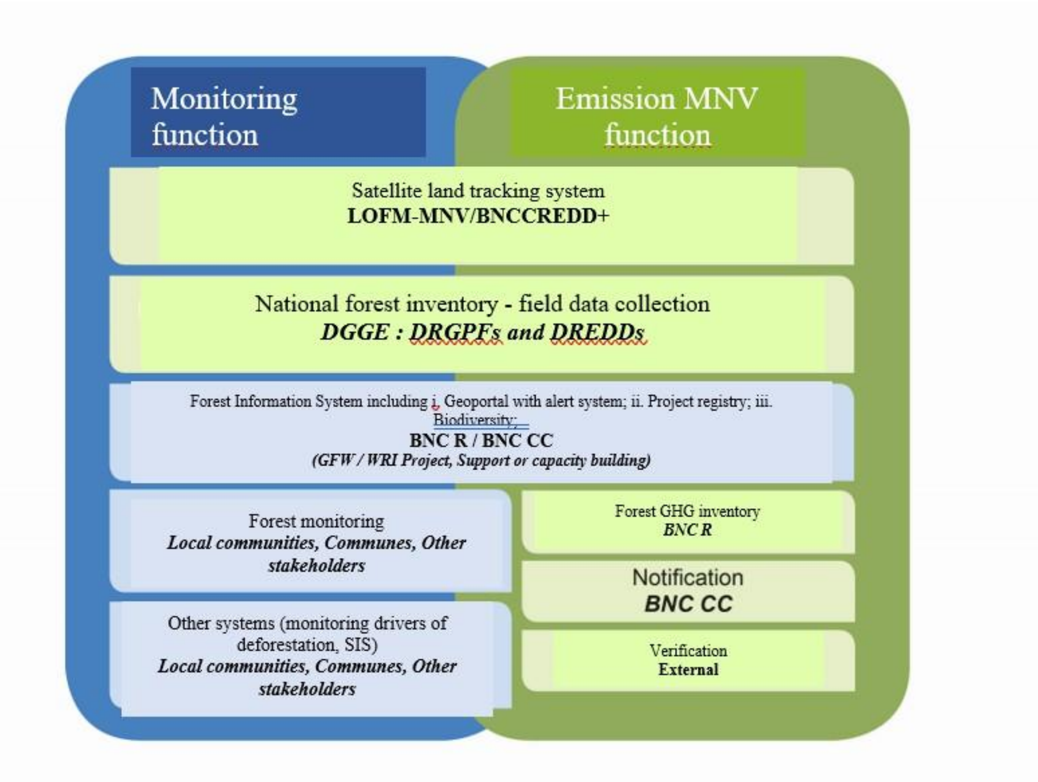
		Madagascar Forest Observation Laboratory Division (LOFM) **<u>Roles and responsibilities</u>** - Ensure cartographic production and generation of forest statistics with protocols and manuals for each process - Ensure the adoption of the Land Use and Occupancy classification systems and forest definitions as national standards - Develop, formalize and popularize standard tools for monitoring forest cover (national grid...) and their guides for use by third parties - Have a cartographic database/metadata, satellite images, statistics, reports - Develop and implement the Satellite Land Monitoring System - Collect, ensure and control the quality of data on land use change and forest area, and perform analyses - Conduct spatial analyses including descriptive causes of deforestation and degradation - Monitor changes in national forest cover, at administrative scales as needed (deforestation rate per Commune ...) and in Programs and Initiatives - Store and make available information to meet reporting obligations at both national and international levels and for decision making by decision makers - Contribute to the measurement of carbon performance by making available information on forest cover dynamics - Participate in the calculation and reporting of carbon performance based on a transparent and reliable methodological process in coordination with the Methodology - To ensure its operation, the LOFM and the Methodology Division work in collaboration and have six (06) staff, namely - One (01) Head of Laboratory who coordinates the activities of the Laboratory - A Methodology Manager who ensures the follow-up of the forest inventory, the calculation of emission factors and performance - Four (04) operators who ensure activity data collection, data processing and analysis, mapping of Land Use and Occupancy (LUO) The work carried out at LOFM follows well-defined standard procedures or Standard Operating Procedures (SOPs) : - The SOP on stratification map creation: SOP0 - The SOP on sampling: - SOP1 - The SOP on data interpretation (response system): SOP2 - The SOP on data collection: SOP3 - The SOP on data Analysis: SOP4 -

		(Link to FCPF forms :https://drive.google.com/file/d/1JqTAIKmA0Xy6Wwbn52nFJiaw 0f8i5tbk/view?usp=sharing) Remote sensing analyses are conducted by a remote sensing laboratory that was established in 2018 under the mandate of BNCCREDD+. This laboratory named "Laboratoire d'Observation des Forêts de Madagascar" (LOFM, Forest Observation Laboratory of Madagascar) is determining the ER Program activity data (baseline and monitoring period); the activity data to monitor emissions and removals at the national scale. The DGGE (including the DRGPF which is responsible for implementing the national forest inventory) has provided recent inventory data to the BNCCREDD+. The Directorate General for Environmental Governance (DGGE) is responsible for overseeing the implementation of national policies related to environmental governance and forest resource management. Through its technical directorates, the DGGE contributes to forest monitoring activities and the generation of forest-related data. Under the DGGE, the Directorate of Reforestation and Landscape and Forest Management (DRGPF) is responsible for implementing the National Forest Inventory (NFI), which provides key information on forest resources and constitutes an important source of data for the National Forest Monitoring System (NFMS). The Directorate of Protected Areas, Renewable Natural Resources and Ecosystems (DAPRNE) contributes data related to protected areas and ecosystems, including official protected area boundaries and monitoring information on environmental pressures, such as burned areas, which may support forest monitoring and reporting activities. The DGGE, through the DRGPF, provides National Forest Inventory data to the National REDD+ Coordination Office (BNCCREDD+). The BNCCREDD+ coordinates the NFMS within the REDD+ framework, integrates data from multiple sources, conducts analyses required for Measurement, Reporting and Verification (MRV), and prepares reports submitted under the mechanisms of the United Nations Framework Convention on Climate Change (UNFCCC). Local communities and so-called REDD+ "initiative" projects are sources of information on performance, illegal logging activities, loss events, poaching, and irregularities in the REDD benefit-sharing process. Community-based monitoring activities exist in areas where government presence is weak. Local or grassroots communities involved in forest management through agreements with the Ministry responsible for forests contribute to forest monitoring activities through community-based forest patrols and the collection of ecological monitoring data. They provide field information on forest conditions, pressures, illegal activities, and observed changes to local forestry authorities. These community-based monitoring data complement other sources of information used within the National Forest Monitoring System (NFMS). Studies conducted in the Eastern humid forests funded by the World Bank and FCPF in 2017 with Salva Terra, identified drivers of deforestation and forest degradation. Deforestation and degradation monitoring activities conducted by LOFM on the year 2023 and 2024 for the monitoring period 2021-2022 were based on interviews, focus groups, and field visits within the forests of the initiatives' areas and in the so-called buffer zone of the initiatives' boundary. This was done for a sample of REDD+ initiative areas in the SAVA, Sofia and Analanjirofo Regions considering also the Alaotra Mangoro and Atsinanana zones for the interviews. BNCCREDD+ prepares and compiles the results of the measurement, monitoring and reporting

		activities into the monitoring report submitted to the FCPF for external verification. The directorates within the ministry in charge of forests thus contribute to field data collection (e.g., through forest inventories) and monitoring activities. Local communities play a similar role. Universities and other organizations participate in research relevant to data processing or standards—such as developing local allometric equations. The LOFM-MRV team is responsible for generating activity data and emission factors. It also prepares the emission reduction report for the ERP program, with input from other technical teams at the BNCCREDD+. The ERP report is then submitted to the FCPF and undergoes external verification. Once verified, notified, and validated, the report is published on the FCPF website. Data produced by the LOFM or other directorates within the ministry in charge of forests will also be useful for the greenhouse gas inventory, which involves the participation of the BNCC and MRV teams. Finally, the BNCC team handles the submission of the BUR or NC to the UNFCCC. The organizational structure of the monitoring, reporting, and verification system (i.e., those functions of the NFMS that are limited to accounting for emissions/removals) is illustrated in the figure below.

		
Selection and management of GHG data and information	Methods and standards for data generation, storage, aggregation and reporting	The ER Program's Forest Monitoring System (FMS) is integrated with the New National Forest Monitoring System (NFMS). This NFMS is established in accordance with Copenhagen Decision 4/C.15 and has two main functions: a monitoring function and a measurement, reporting and verification (MRV) function. The monitoring function is used to monitor legal compliance, safeguards and other aspects of the ER Program. Monitoring data are generated according to standard operating procedures and correspond to the ER Program approaches in terms of forest definition, forest type definition, activity selection, pre-processing and processing methods, emission factors, change category uncertainties and overall uncertainties, etc. These monitoring data can be found in the following documents : - Legal documents (title transfer and access to the Carbone revenue) https://www.environnement.mg/wp-content/uploads/2025/06/DRMCF-portant-sur-le-Decret-2025-626-relatif-a-la-regulation-de-l-acces-au-marche-du-carbone-forestier.pdf - Safeguards documents https://www.environnement.mg/organisme-rattache/redd/ or https://drive.google.com/drive/folders/10UgMDUpatirPrvaO65ARohTgctjZNgqW?usp=share_link - MRV documents (https://drive.google.com/file/d/1Wv0i1MHSlhkAfxTiQSW0RVNa_Hc29mN-/view?usp=drive_link and https://drive.google.com/file/d/18W4Chq8WwCo7hZL0fXyACpsJAkfoiI8Y/view?usp=sharing ; https://drive.google.com/file/d/1pSqv1RAsH3VY2Eru8D_wWHXKN6RBEHWD/view?usp=drive_link)) - Land use map and processes (SOP0)Activity data and map (https://drive.google.com/file/d/18mDgiuv3LVvrdMrrzeCbHC_67Nw_vQm0/view; https://drive.google.com/drive/folders/1O2pUXfjUJ1s5_Cy83DrlfrXOIBqn0US7?usp=sharing, https://drive.google.com/file/d/12XzSDAtmOs4MVOhclR_EVl-XlMFfFw1H/view?usp=drive_link)

		(in the MNV Standard tab), which is an inherent part of the NFMS. Inventory results are stored in the same way. This approach ensures that the data is stored and is publicly available. **<u>Structure of the NFMS</u>** The MRV function of the NFMS is strictly related to the estimation, reporting and verification of GHG emissions and removals.



Data produced by the LOFM-MNV and other directorates within the ministry responsible for forests (e.g., data on reforestation areas, deforestation, avoided deforestation, etc.) were used for the greenhouse gas inventory. The BNCC and MNV team participates in the greenhouse gas inventory process. Finally, the BNCC team submits the BUR or NC to the UNFCCC.

The national forest monitoring system—comprising the Satellite Land Monitoring System and the MRV system managed by the BNCCREDD+—was designed starting in 2018. Standard procedures were established by Madagascar's Forest Observation Laboratory (LOFM) to guide the systems' application during monitoring and tracking activities. Staffed by experienced specialists, the LOFM ensures the systems' long-term viability; the supporting standard procedures were developed by the laboratory to guarantee that the system remains functional and sustainable.

Data processing:
The REDD + Initiatives and Programs Information System or SIIP is a secure computer system that aims to assist the management and monitoring of REDD+ initiatives and programs.
It collects, saves, processes, classifies and disseminates all information related to the management, monitoring and evaluation of REDD+ activities and its actors.

The SIIP ensures transparency in the implementation of REDD+ activities, the implementation of benefit sharing and the monitoring of performance generated by REDD+ Initiatives and Programs. The SIIP consists of a set of (i) data, (ii) procedures, (iii) processing and (iv) reporting. Its mandate is as follows:

- Validate and formalize all information on REDD+ initiatives and programs;
- Centralize, compile and process information provided by the different actors;
- Manage the confidentiality and security of REDD+ data;
- Establish traceability and alert of pending situations such as pending complaints, lack of financial reporting, or others;

		- Share decision information according to the needs of different actors as well as accountability information for REDD+ governance structures, in public or private form; - Provide information for the evaluation of the performance of each actor within each initiative; - Disseminate information on the performance of REDD+ initiatives and programs as well as the spatialization of REDD+ funding; - Ensure consistency between information on ER performance and the creation of "carbon stocks" through the Transactional Registry. Emissions by sources and removals by sinks measured, monitored, and reported by FMS are consistent with those reported by the RL (as required by Criterion 14 of the Methodological Framework).

		This was done through four main principles: ▪ Consistent scope: The same scope in terms of geographic area, REDD+ activities, carbon pools, and greenhouse gases retained from the RL (CF MF indicator 14.1); ▪ Activity Data (AD): Data on the extent of human activity resulting in emissions or removals during a given time period were measured and monitored using the same methods used to define it in the RL (CF MF Indicator 14.2); ▪ Emission factors (EFs) and default values: The same EFs and default values used for the RL were s used in the estimation of GHG emissions by sources and removals by sinks (CF MF Indicator 14.3); ▪ GHG accounting: the same equations, calculation procedures, and QA/QC as used for the RL were used (CF MF Indicator 14.1). The only parameters being changed with respect to the RL are the activity data.
Processes for collecting, processing, consolidating, and reporting GHG data and information - Systems and processes that ensure the accuracy of data and information - Design and maintenance of the Forest Monitoring System		The overall measurement, monitoring, and reporting process includes all Earth Observation (EO) data collection operations, Quality Assurance (QA) operations, and final reporting. Data collection and processing were performed to produce activity data in the form of: subcategory/land use strata conversion area (A(j, i), A(i,j)). Key specifications for data collection and processing are shown in Section 3.2. Once the emission reductions have been calculated, they will be reported with all information provided in a transparent manner demonstrating that the principles outlined in Section 9.1 have been followed. Any interested organization or individual can find this information on the website of the Ministry of the Environment and Sustainable Development, where the report for the first period containing section 9.1 can be found (link: https://www.environnement.mg/wp-content/uploads/2024/07/ER_monitoring_report_First_period_ERPAA_10052023.pdf).. The system and processes that support the Forest Monitoring System are in place: - Satellite Land Monitoring System - MRV As stated previously in the paragraph on the organizational structure, responsibilities, skills, the work carried out within the LOFM follows well-defined standards of Procedures or Standard Operating Procedures (POS), these are: The work carried out at LOFM follows well-defined standard procedures or Standard Operating Procedures (SOPs) : - The SOP on stratification map creation: SOP0 - The SOP on sampling: - SOP1 - The SOP on data interpretation (response system): SOP2 - The SOP on data collection: SOP3 - The SOP on data Analysis: SOP4 Each SOP has its own objective, namely: -For the SOP 0 concerning the Mapping of Land Use and Occupation changes for stratification; it is to detail the procedures for creating a map of land use and cover and these changes in order to prepare a stratified random probability sample. -SOP1 on Sampling Design preparation is used to establish a spatially referenced, probability-based and geographically balanced sampling design for area estimation in terrestrial surveys. It is applicable for monitoring with stratified sampling.

		-The SOP on the forest inventory guidelines (https://drive.google.com/file/d/1Wv0i1MHSlhkAfxTiQSW0RVNa_Hc29mN-/view?usp=drive_link and https://drive.google.com/file/d/18W4Chq8WwCo7hZL0fXyACpsJAkfoiI8Y/view?usp=sharing) -SOP2 for response design explains how to assign labels (e.g.: land cover/land use class) to a sample unit. The response plan allows for the best available classification of change for each sampled spatial

		unit and contains all the information needed to replicate the process of assigning a label to the sampled unit. The response design defines an objective procedure that interpreters can follow that reduces interpreter bias. - SOP3 gives details on data collection and details how to set up and run data collection for sample-based visual interpretation primarily using remote sensing data to collect sample information. Finally, SOP4 is about data analysis and provides area estimates and their uncertainties through the combined use of reference data and maps. QA/QC procedures are applied, specifically for the collection and updating of activity data, namely: - During the creation of the stratification map, a quality assessment of the classification is carried out using the confusion matrix, and by calculating the errors of omission and errors of commission. What is important to note is the skip and commission value for the change class. These numbers should be small enough to use the map (https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhlrSy7sbU_5m/view?usp=sharing - When collecting activity data in the Collect Earth tool: In general, once you fill in the information on a plot, you have to check the information included. Especially if the assigned change of cover and the classes of the two dates studied are logical. You have to have reasoning and correspondence. An operator other than the one who performed the data collection retests a random sample of 20 percent of the total number of samples during Quality Assurance. For quality control, 5% of the added samples of all change classes and those with low confidence are reanalyzed by the group (https://drive.google.com/file/d/1Qf4PIgjvx03clSYtpbhC9_HboXIRP1go/view?usp=sharing). - During data analysis: The Laboratory and Methodology Manager, in coordination with the analysts, checks that the calculations comply with SOP4 on data analysis, including the script used for the calculations. Then they cross-check the estimates with previously reported estimates for the same classes. Estimates are further cross-checked and compared to estimates reported by other sources (e.g. Global Forest Resources Assessment, National Greenhouse Gas Inventory, UNFCCC reports, Global Forest Watch **…**) **(**https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing).
The role of communities in the Forest Monitoring System;		Communities participate in the forest monitoring system through patrols. They can provide sources of information on the history of REDD+ intervention sites. They can also work closely with the agents responsible for monitoring (CRR, BNCCREDD agents, deconcentrated MEDD services, DREDD) during the forest monitoring phase for data collection, data verification…
The use of and consistency with technical procedures operational in the country, and their consistency with the National Forest Monitoring System.		The basic technical procedures (activity data collection, NERF/NRF calculations, emission reductions) are applied at the national level, thus uniform in the country. The standard national process and procedures are enforced by the Decree on the regulation of access to the forest carbon market. The tools and methods used are consistent with the existing national forest monitoring system.

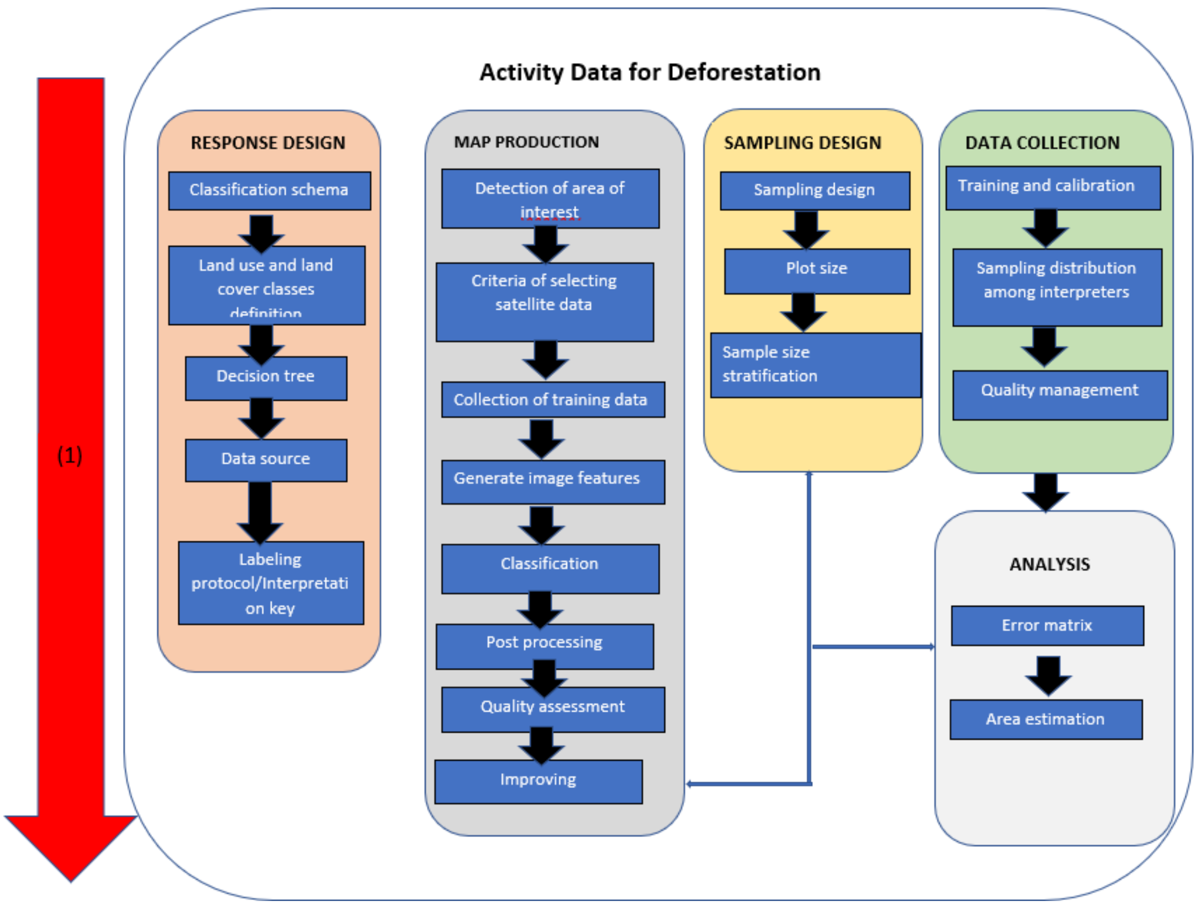
2.2 Updates to the monitoring approach

For this monitoring period (2023-2024), there was no change for the monitoring approach.

2.3 Measurement, monitoring and reporting approach

2.3.1 Line Diagram

The following figure illustrates the workflow for calculating emission reductions during the monitoring period. Note that this workflow, including the reporting phase, is implemented by the LOFM Division and MRV of BNCCREDD+.



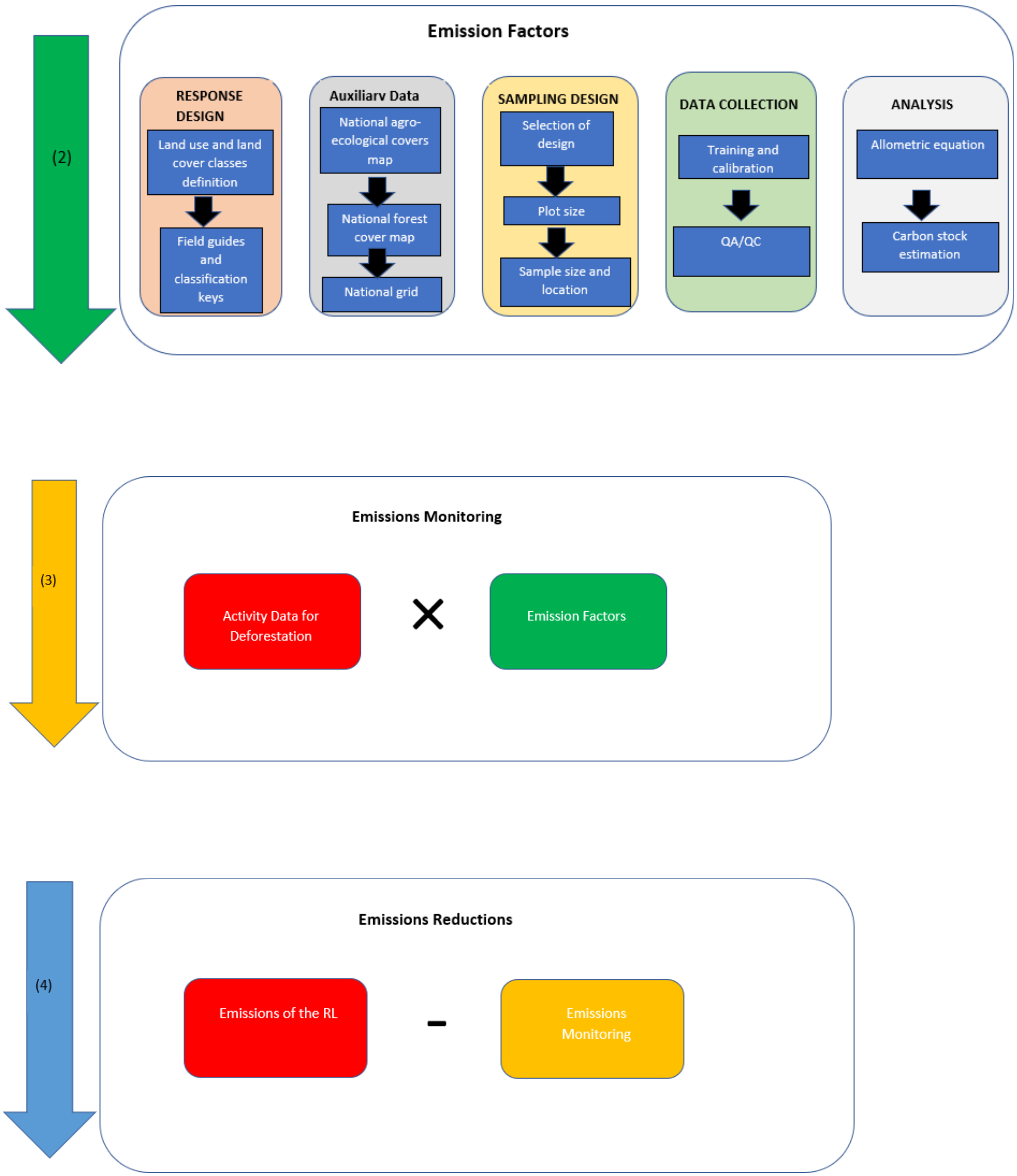


Figure 1 : Workflow on emission reduction calculation

ACTIVITY DATA FOR DEFORESTATION

5 steps: methodological design, map production, sampling plan design, data collection, and result analysis.
RESPONSE DESIGN: this is the step of designing the response.
Classification scheme: defines the classification scheme;
Definition of land use and land cover classes: defines the different types of classes (Land Use and Land Cover classes);
Decision tree: provides a set of logical rules to guide and ease decision-making for classification during observations;
Data source: determines the information sources (examples: satellite images like Sentinel, Landsat, Google Earth platform…);
Labeling protocol / interpretation key: provides the interpretation key

MAP PRODUCTION: step in the production of the stratification map
Detection of area of interest: determination of the area being monitored and the corresponding image tiles.
Criteria for selecting satellite data: these criteria mainly concern spatial resolution, cloud cover, the image acquisition period, their temporal consistency, and their availability.
Collection of training data: this activity involves collecting training areas for the different defined classes to feed the classification algorithm.
Generate image features: extraction of spectral bands, allowing the algorithm to better distinguish between the different classes.
Classification: this is the step during which each pixel or object in the image is assigned to a class for the stratification map.
Post processing: intended to remove isolated errors, correct spatial inconsistencies, and improve the continuity of the map's classes.
Quality assessment: a quality evaluation is carried out to measure the classification's performance.
Improving: the identified errors lead, if necessary, to an improvement phase.

SAMPLING DESIGN: The stratification map produced does not by itself provide a definitive estimate of deforested areas; it is then used as a stratum for stratified random sampling to estimate the deforested area.
Sampling design: choosing the type of sampling (for example: stratified random sampling).
Plot size: choosing the plot size or the size of the sampling unit for observation (for example: 0.5 ha, which corresponds to the minimum area in the definition of forests).
Sample size stratification: size and distribution of samples within the strata (for example: random distribution and type of optimal distribution, that is, according to standard errors).

DATA COLLECTION
Training and calibration: Before starting the data collection work, interpreters participate in training and calibration sessions aimed at harmonizing interpretations.
Sampling distribution among interpreters: The samples are then randomly distributed among the different operators, and each point will have its class according to the UOT classification and the observed changes.
Quality management: Throughout the process, a quality assurance and control system is applied. This includes internal checks, cross-checks between interpreters, and reviews of observations that show discrepancies. These measures help ensure the consistency and reliability of the activity data used in analyses for estimates.

ANALYSIS
Error matrix: The data from the classification are compared to reference data in order to build a confusion matrix.
Area estimation: The areas are estimated for each class (activity data)

EMISSION FACTORS

Methodological steps for producing emission factors to estimate carbon stocks resulting from land use changes and deforestation including five main steps: methodological design, collection of auxiliary data, sampling plan design, field data collection, and data analysis.

RESPONSE DESIGN: The first step is to define the methodological framework that will guide the entire forest inventory. Land use and land cover classes definition: these are the LULC (land use and land cover) classes; they are more detailed to distinguish between different land use and land cover types.
Field guides and classification keys: These documents describe the standardized methods for collecting forest data, the criteria for species identification, the procedures for measuring trees, as well as the rules to ensure a consistent interpretation of field observations.
AUXILIARY DATA: Before implementing the forest inventory, several sets of spatial data are used to prepare the sampling plan and improve the representativeness of the inventory.
National agro-ecological cover map: This map helps identify the different ecological regions of the country with relatively homogeneous climatic, soil, and biological conditions.
National forest cover map: which provides a spatial representation of forest distribution.
National grid: spread with a size of 4km*4km across the whole territory, this grid serves as the spatial support for the future forest inventory.

SAMPLING DESIGN: Selection of design: The inventory plot sampling used is stratified random sampling based on the national grid. The stratum considered here is the forest stratum.
Plot size: The plot size is 50m x 50m. It is a square plot. The square plot is advantageous for result reliability and less costly compared to installing clusters of 3 circular plots. The center of the plot coincides with the center of the national grid, which allows tracking plots via satellite imagery.
Sample size and location: The sample size must be representative of the area or ecoregion. Sampling was carried out in the humid forest ecoregion.

DATA COLLECTION:
Training and calibration: Before starting the work, the teams undergo training and calibration. This step aims to standardize measurement techniques, especially for diameter at breast height (DBH), tree height, species identification, and other forest variables. Calibration also helps ensure that all teams are applying the same protocols consistently.
QA/QC: This involves field checks (inventory supervision), verification of inventory sheets, repeated measurements on certain plots, and database validation procedures. These mechanisms help quickly catch measurement errors, inconsistencies, or outlier values and improve the overall quality of the collected data.

ANALYSIS: The data collected in the field is analyzed to estimate the carbon stocks of different types of forests.
Allometric equation: allows estimating the biomass of trees based on the variables measured in the field, mainly diameter, height, and, when possible, wood density.
Carbon stock estimation : The biomass estimates obtained are then converted into carbon stocks. Carbon stocks are calculated for the different pools considered in the inventory, including aboveground biomass, belowground biomass, dead wood, litter, and, depending on the study objectives, soil organic carbon.

2.3.2 Calculation

The equations below show the calculation of the Emission Reduction as well as the emissions during the monitoring periods. The following links show how to calculate these parameters.

Link : Calculating emission reductions :

https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true

Biomasse Madagascar :

https://docs.google.com/spreadsheets/d/1IKaSEziwEhijIPsdFNg1DGnAjBqVotdr/edit?usp=sharing&ouid=114519974924085988913&rtpof=true&sd=true

The data used comes from the traitement 2020 sheet. No new data is available following the 2020 inventory

EMISSION REDUCTION CALCULATION

In order to execute this operation of the process, the same IPCC methods and equations described in Chapter 8.3 (Annex 4) of the MR1 (cf table below) will be used to estimate GHG emissions in the monitoring period.

Table 3 : Summary of the equations and the Tier applied

Source/Sink	Pool	Methods	Tier
Deforestation	Biomass	Equation 2.16 and 2.8b of 2006 IPCC Volume 4 GFOI MGD, Chapter 3.1.2	Tier 2 (above-ground) Tier 1/2 (belowground)
	Dead Organic Matter (Dead wood and litter)	Equation 2.23 of 2006 IPCC Volume 4	Tier 2 (Dead wood) Tier 1 (Litter)
	Soil Organic Carbon	Equation 2.25 2006 IPCC GL Volume 4	Tier 2
	Non-CO2 emissions	Equation 2.27 2006 IPCC GL Volume 4	Tier ½
Forest Degradation	Biomass	GFOI MGD, Chapter 3.1.3	Tier 2 (above-ground) Tier 1/2 (belowground)
Enhancement of carbon stocks	Biomass	GFOI MGD, Chapter 3.1.4	Tier 2 (above-ground) Tier 1/2 (belowground)

The following equations would be applied to estimate the Emission Reductions in year t:

$$ER_{ERP,t} = RL_t - GHG_t \quad \textbf{Equation 1}$$

Where:

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

RL_{RP} = *Gross emissions of the RL from deforestation over the Reference Period; $tCO_2e*year^{-1}$. This is sourced from Annex 4 of the MR1 (*https://docs.google.com/document/d/1ck2jZj-yIyLPndafoYaaHEDXBgP9zJ8F/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true) *and equations are provided below.*

GHG_t = *Monitored gross emissions from deforestation at year t; $tCO_2e*year^{-1}$;*

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

MONITORED EMISSIONS (GHGT)

$$\boldsymbol{GHG_t} = \sum_{i} \Delta \mathbf{C_{B,t,i}} + \Delta \boldsymbol{C_{DOM,t,i}} + \Delta \boldsymbol{C_{SOC,t,i}} + \boldsymbol{L_{fire,t,i}}$$ **Equation 2**

Where:

$\Delta \mathbf{C_{B,t,i}}$	=	Changes in carbon stocks in biomass from REDD+ activity i in year t; tCO_2e year^{-1}.
$\Delta \boldsymbol{C_{DOM,t,i}}$	=	Changes in carbon stocks in Dead wood and Litter from REDD+ activity i in year t; tCO_2e year^{-1}.
$\Delta \boldsymbol{C_{SOC,t,i}}$	=	Changes in Soil Organic Carbon from REDD+ activity i in year t; tCO_2e year^{-1}.
$\boldsymbol{L_{fire,t,i}}$	=	Non-CO2 emissions from fire in REDD+ activity i in year t; tCO_2e year^{-1}.

Equations for the estimation of the different activities, deforestation, forest degradation and enhancement of carbon stocks is provided in the next sections.

Deforestation

<u>Changes in carbon stocks in biomass</u>

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

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

Where:

ΔC_{B_t}	Annual change of total biomass carbon stocks during the period, in tC per year;
ΔC_G	Annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tC per hectare and year;
$\Delta C_{CONVERSION}$	Initial change in carbon stocks in biomass on land converted to other land-use category, in tC per hectare and year; 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 tC per hectare and year.

Following the recommendations set in chapter 2.5.1.1 of the GFOI Methods Guidance Document for applying IPCC Guidelines and guidance in the context of REDD+[*], the above equation will be simplified and it will be assumed that:

- The annual change in total biomass carbon stocks (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$);

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[*] https://www.reddcompass.org/mgd/resources/GFOI-MGD-3.1-en.pdf

Considering equation 2.16 of the 2006 IPCC GL for estimating ($\Delta C_{CONVERSION}$) the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_t} = \sum_{j,i} \left(AGB_{Before,j} x (1 + R_j) - AGB_{After,i} x (1 + R_i) \right) \text{ x CF x} \frac{44}{12} \times A(j,i)_t$$ **Equation 3**

Where:

$A(j,i)_t$ — Area of forest converted from forest to non forest during the monitoring period, in hectare per year. In this case, four possible conversions are possible:

- **Primary forest to non-forest (DPF);**
- **Disturbed Forest to Non-Forest (DDF);**

- **Secondary Forest to Non-Forest (DSF);**
- **Agroforestry to Non-Forest (DAF);**
  Plantations to Non-Forest (DPL);

The description of this parameter may be found in **Section 3.2.**

$\mathrm{AGB}_{\mathrm{Before,j}}$ Aboveground biomass of forest type j before conversion, in tons of dry matter per ha. This can be the aboveground biomass of the following two types of forest:

- **Primary forest (PF);**
- **Disturbed Forest (DF);**
- **Secondary Forest (SF);**
- **Agroforestry (AF);**
- **Plantations (PL);**

The classes corresponding to these forest categories are shown in the table below :

Category	**Class**
Primary Forest (PF)	Dense humid Forest
Disturbed Forest (DF)	Degraded humid Forest
Secondary Forest (SF)	Secondary Forest
Plantations (PL)	Plantation

The description of this parameter may be found in **Section 3.1.**

Rj ratio of below-ground biomass to above-ground biomass for a specific vegetation type, in ton d.m. below-ground biomass (ton d.m. above-ground biomass)$^{-1}$. This is equal to:

- **0.2** is the default for tropical moist deciduous forest when aboveground biomass is <125 t.d.m./ha according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for Secondary Forest and Agroforestry.
- **0.24** is the default for tropical moist deciduous forest, >125 t.d.m./ha according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for primary forest and disturbed forest.
- **3.24** is the root shoot ratio of Eucalyptus plantations from ERPD Atiala Atsinanana document, 2018, tables 60 and 63 (link : https://drive.google.com/file/d/1gzR9Kz8UYOJ-6PNbzOsjrilMohy1oCIA/view?usp=drive_link) and the RSR value interval according to RAZAKAMANARIVO et al. (2011). This is the case for Plantations.

$\mathrm{AGB}_{\mathrm{After,i}}$ Aboveground biomass of non-forest type I after conversion, in ton dry matter per ha. This is the aboveground of **non-forest (NF)**.

The description of this parameter may be found in **Section 3.1.**

R_i ratio of below-ground biomass to above-ground biomass for a specific vegetation type i, in ton d.m. below-ground biomass (ton d.m. above-ground biomass)$^{-1}$. This is equal to:

- **0.2** is the default for tropical moist deciduous forest when aboveground biomass is <125 t.d.m./ha according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for <u>non-forest</u>.

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

<u>Changes in carbon stocks in Dead wood and Litter</u>

Considering equation 2.23 of the 2006 IPCC GL for estimating ΔC_{DOM}, the change in dead organic matter carbon stocks could be expressed with the following equation.

$$\Delta C_{DOM,t} = \frac{(C_n - C_o) x\, A(j,i)_{\mathrm{t}}\, x \frac{44}{12}}{T_{on}}$$ **Equation 4**

Where :

$A(j,i)_{\mathrm{t}}$ area undergoing conversion from old to new land-use category, hectare per year. This is the same as parameter (j,i) above. The description of this parameter may be found in **Section 3.2.**

C_o dead wood/litter stock, under the old land-use category, tonnes C ha-1.

For dead wood it will have different values for each of the following forests:

- **Primary forest (PF);**
- **Disturbed Forest (DF);**
- **Secondary Forest (SF);**
- **Agroforestry (AF);**
- **Plantations (PL);**

The classes corresponding to these forest categories are shown in the table below :

Category	**Class**
Primary Forest (PF)	Dense humid Forest
Disturbed Forest (DF)	Degraded humid Forest
Secondary Forest (SF)	Secondary Forest
Plantations (PL)	Plantation

For Litter, a default value for tropical broadleaf forests of **2.1** tC/ha has been used. This has been sourced from 2006 IPCC GL, TABLE 2.2, Volume 4, Chapter 4.

C_n dead wood/litter stock, under the new land-use category, tonnes C ha-1. It has been assumed that this is **zero**.

T_{on} time period of the transition from old to new land-use category, yr. The Tier 1 default is **1 year** for carbon losses, so it has been assumed one year.

$44/12$ Conversion of C to CO2

<u>Changes in Soil Organic Carbon</u>

Since in the ER program area there are only mineral soils, considering equation 2.25 of the 2006 IPCC GL for estimating ΔC_S, the change in soil organic carbon could be expressed with the following modified equation.

$$\Delta C_{SOC,t} = \frac{\sum_{\boldsymbol{j,i}} \left(\left(SOC_{Before,j} - SOC_{After,i} \right) \times \frac{44}{12} \times \sum_{t=0}^{t} A(j,i)_{\mathrm{t}} \right)}{D}$$ **Equation 5**

Where :

$A(j,i)_{\mathrm{t}}$ land area of the stratum being estimated, hectare per year. This is the same as parameter $(\boldsymbol{j},\boldsymbol{i})$ above but in the case of SOC the annual this represents the cumulative area since the beginning of the crediting period.
description of this parameter may be found in **Section 3.2.**

$SOC_{Before,j}$ the reference carbon stock, ton C ha^{-1} for forests. It has been assumed the same value for the fo forest types.

- **Primary forest (PF);**
- **Disturbed Forest (DF);**

For plantations and Agroforestry it is not accounted for.

$SOC_{After,i}$ the carbon stock, ton C ha^{-1} for **non-forest (NF).**

$44/12$ Conversion of C to CO2

<u>*Non-CO2 emissions from deforestation*</u>

Following the Equation 2.27 of Volume 4 of the 2006 IPCC GL, GHG emissions from forest fires ($L_{fire,}$) are estimated with the following equation:

$$L_{fire,t} = A_{\mathrm{t}} x M_B x C_f x G_{ef} x 10^{-3}$$ **Equation 6**

<u>Where :</u>

A_{t} area burnt, hectares per year, which is equivalent to $A(j,i)$ Area of forest converted from forest to non-forest during the monitoring period, in hectare per year. The description of this parameter may be found in **Section 3.2.** This could be the following conversions :

- **Primary forest to non-forest (DPF);**
- **Disturbed Forest to Non-Forest (DDF)**
- **Secondary Forest to Non-Forest (DSF)**
- **Agroforestry to Non-Forest (DAF)**
- **Plantations to Non-Forest (DPL)**

M_B mass of fuel available for combustion, tonnes ha^{-1}. This is equivalent to the biomass prior to conversion $\boldsymbol{AGB_j}$**.** This is the aboveground biomass in forest areas as afforestation/reforestation does not involve burning prior to conversion.

C_f combustion factor, dimensionless. This is equal to:

- **0.5** for primary forest, as it is the value for primary tropical forest (slash and burn) according to 2006 IPCC GL Table 2.6
- **0.55** for modified natural forest, as it is the value for secondary tropical forest (slash and burn) according to 2006 IPCC GL Table 2.6

G_{ef} emission factor, g kg^{-1} dry matter burnt. This is equal to:

- **6.8** for CH4 as it is the value for tropical forest according to 2006 IPCC GL Table 2.6
- **0.2** for N2O as it is the value for tropical forest according to 2006 IPCC GL Table 2.6

$$L_{fire,t} = A(j,i)_{\mathrm{t}} x AGB_{Before,j} x C_f x (G_{ef_{ch4}} x GWP_{CH4} + G_{ef_{N2O}} x GWP_{N2O}) x 10^{-3}$$ **Equation 7**

Where :

GWP_{CH4} Global Warming Potential of CH4, = 28

GWP_{N2O} Global Warming Potential of N2O, = 265

Values from the last AR5 are used as recommended, all the numbers updated accordingly

Global Warming Potential (GWP) of CH4 and N2O value can be found on the link .
https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf .

Reducing Emissions from Degradation / Forest Land remaining Forest Land

Following the recommendations set in chapter 2.5.1.2 of the GFOI Methods Guidance Document, GHG emissions from degradation will be estimated by taking "account of long-term reductions of carbon densities due to transitions between forest strata and sub-strata, and within the strata and substrata affected by human activity (i.e. MNF and planted forests)". In essence this means, by multiplying activity data of transition between different types of forest by the difference in average carbon stocks.

Considering equation 2.16 of the 2006 IPCC GL for estimating $\Delta C_{CONVERSION}$ and considering 2.8 b for the estimation of carbon stocks, the change of biomass stocks ($\Delta C_{B,t}$) could be expressed with the following equation.

$$\Delta C_{B,t} = \sum_{j,i} \left(AGB_{Before,j} x(1+R_j) - AGB_{After,i} x(1+R_i)\right) x\ CF\ x \frac{44}{12} \times A(j,i)_t \qquad \textbf{Equation 8}$$

Where :

$A(j,i)_t$ Area of forest converted from primary forest to modified natural forest - disturbed forest or to plantation during the monitoring period, in hectare per year. The description of this parameter may be found in **Section 3.2.**This could be the following conversions:

- **Primary forest to Disturbed Forest (D-PF DF);**
- **Primary forest to Agroforestry (D-PF AF);**
- **Primary forest to Plantations (D-PF PL);**
- **Disturbed Forest to Agroforestry (D-DF AF)**
- **Disturbed Forest to Plantations (D-DF PL)**

$AGB_{Before,j}$ Aboveground biomass of forest type j before conversion, in ton of dry matter per ha. This is the aboveground biomass of **Primary forest (PF)** or **Disturbed Forest (DF).** The description of this parameter may be found in **Section 3.1.**

Rj ratio of below-ground biomass to above-ground biomass for a specific vegetation type, in ton d.m. below-ground biomass (ton d.m. above-ground biomass. This is equal to:

- **0.24** is the default for tropical moist deciduous forest, >125 t.d.m./ha according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for primary forest and disturbed forest.

$AGB_{After,i}$ Aboveground biomass of non-forest type I after conversion, in ton dry matter per ha. This is the aboveground of **Disturbed Forest (DF)** or **Agroforestry (AF)**. In the case of **Plantation (PL)** this is assumed to be zero so as to comply with the requirements on Safeguards of the Cancun agreements. The description of this parameter may be found in **Section 3.1.**

R_i ratio of below-ground biomass to above-ground biomass for a specific vegetation type i, in tonne d.m. below-ground biomass (ton d.m. above-ground biomass)$^{-1}$. This is equal to:

- **0.24** is the default for tropical moist deciduous forest, >125 t.d.m./ha according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for primary forest and disturbed forest.
- **0.2** is the default for tropical moist deciduous forest when aboveground biomass is <125 t.d.m./ha according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for Agroforestry.

CF Carbon fraction of dry matter in tC per ton dry matter. The value used is:

- **0.47** is the default for tropical forest as per IPCC AFOLU guidelines 2006, table 4.3.

$44/12$ Conversion of C to CO2

Enhancement of carbon stocks in new forests / Land Use Change from non-Forest Land to Forest

Following the recommendations set in chapter 3.1.4 of the GFOI Methods Guidance Document, enhancement of carbon stocks in afforestation/reforestation will be estimated by multiplying the activity data by the yield tables or growth curves in the generation of changes in carbon density through time on afforested/reforested lands.

Since there are no such tables in Madagascar in regenerated forest, and according to the table presented in the RE calculation Excel file (link: https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true), on the "biomass" sheet, the estimated time for the conversion of non-forest (young savoka) to secondary forest and agroforestry is 10 years. This value was used to calculate the carbon sequestration for secondary forest and agroforestry. For plantations, the conversion time is 5 years.

The calculation of these values is explained starting on line 69 of the "Suivi" sheet, column I "years" (click on the year values to view the formula) in the MADA Calcul RE file, link : https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true

This is seen as a better option than using averages, which is the alternative proposed in Chapter 3.14 of GFOI which would be a source of bias.

Therefore, the annual change in carbon stocks would be estimated as follows:

$$\Delta C_{B,t} = \sum_{j,i} \frac{(AGB_{Before,i} - AGB_{After,j})}{\text{Years growth}} \, x(1+R)x \; CF \; x \frac{44}{12} \times \sum_{t=0}^{t} A(i,j)_t \qquad \textbf{Equation 9}$$

Where :

ΔC_B	Change of total carbon stocks during the monitoring period, in tC per hectare, per year.
$A(i,j)_t$	Annual conversion from non-Forest Land use i to forest type j (planted forest or modified natural forest). The description of this parameter may be found in **Section 3.2.** Area of forest converted from non-forest to forest during the monitoring period, in hectare per year. In this case, it would be : • **Non-forest to Secondary Forest** • **Non-Forest to forestry**
$AGB_{Before,i}$	Aboveground biomass of non-forest type i before conversion, in ton dry matter per ha. In this case, it would be the aboveground biomass of **non-forest (NF)**. The description of this parameter may be found in **Section 3.2.**
$AGB_{After,j}$	Aboveground biomass of forest type j after conversion, in ton of dry matter per ha. The description of this parameter may be found in **Section 3.1.** In this case, it would be the aboveground biomass of : • **Secondary Forest (SF);** • **Agroforestry (AF);** • **Plantations (PL);**
R	ratio of below-ground biomass to above-ground biomass for a specific vegetation type i, in ton d.m. below-ground biomass (ton d.m. above-ground biomass)$^{-1}$. This is equal to: • **0.2** is the default for tropical moist deciduous forest when aboveground biomass is <125 t.d.m./ha according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for Secondary Forest, Agroforestry and non-forest. • **3.24** is the root shoot ratio of Eucalyptus plantations from ERPD Atiala Atsinanana document, 2018, tables 60 and 63 (link : https://drive.google.com/file/d/1gzR9Kz8UYOJ-

6PNbzOsjrilMohy1oCIA/view?usp=drive_link) and the RSR value interval according to RAZAKAMANARIVO et al. (2011). This is the case for Plantations.

Years growth — Number of years to transit from Non-forest to forest. The value used is:

- **10** years is assumed as the secondary forest is assumed to have 20 years in average and the savouka jeune or non-forest represents a secondary vegetation of 10 years in average.
- **10** years is assumed as the agroforestry is assumed to have 20 years in average and the savouka jeune or non-forest represents 10 years in average.
- **5** years is assumed as the plantation is assumed to have 5 years.

The calculation of these values is explained starting on line 69 of the "Suivi" sheet, column I "years" (click on the year values to view the formula) in the MADA Calcul RE file, link : https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true

CF — Carbon fraction of dry matter in tC per ton dry matter. The value used is:

- **0.47** is the default for tropical forest as per IPCC AFOLU guidelines 2006, table 4.3.

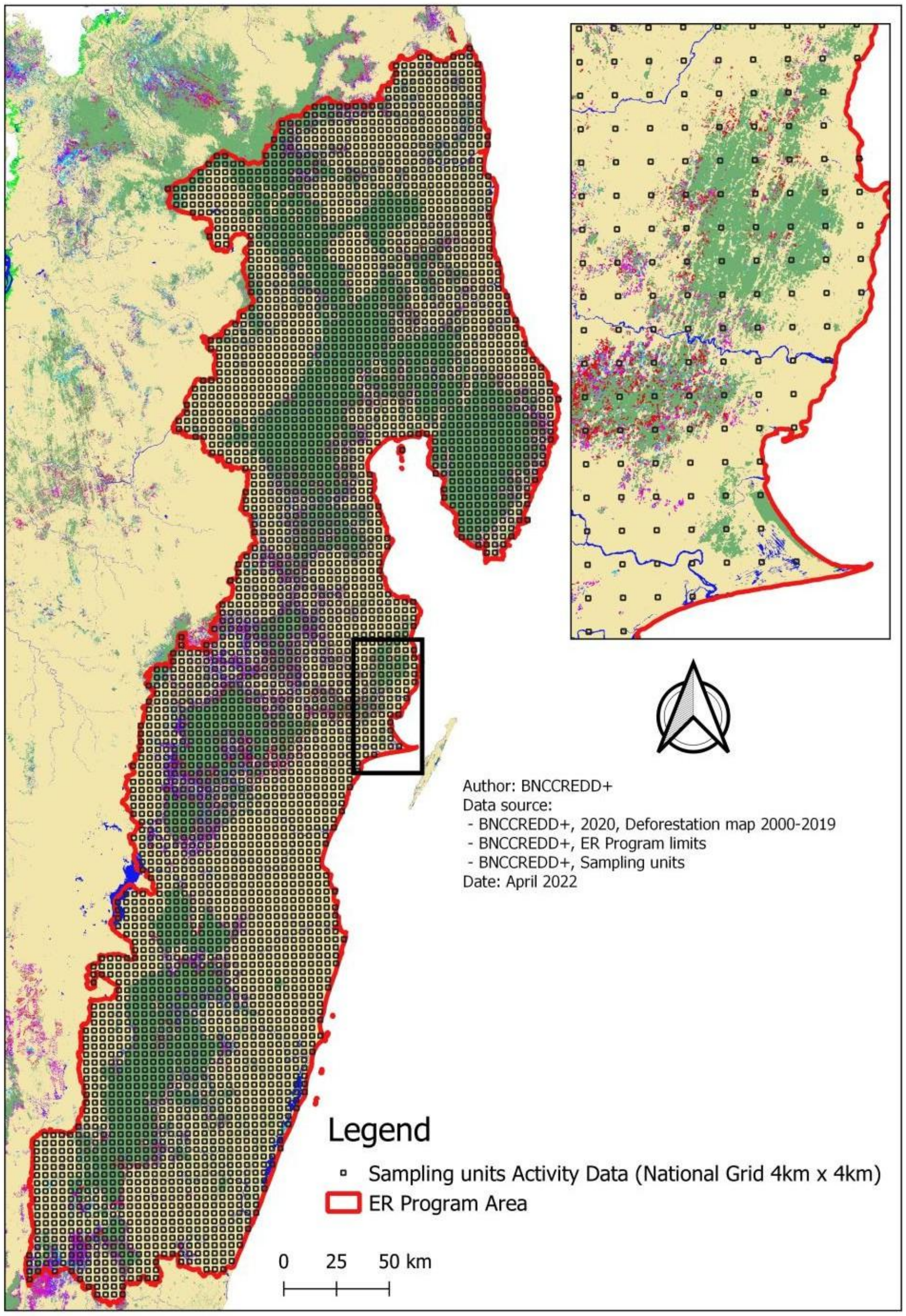
$44/12$ — Conversion of C to CO2

3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

The following tables show activity data for the reference level :

Parameters :	$A(j,i)_t, A(i,j)_t$
Description :	● *Annual conversion from forest type j (primary forest, modified natural forest), to non-Forest Land uses i (Non-Forest) in period 2006-2015* ● *Annual conversion from forest type j (primary forest), to Forest type i (modified natural forest or plantations) in period 2006-2015* ● *Annual conversion from non-Forest Land use i to forest type j (planted forest or modified natural forest) in period 2006-2015*
Data unit :	ha/year
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	As indicated previously, design-based inference has been used to estimate the activity data. Sampling design Estimator: Simple random estimator of a proportion Stratification: No stratification. Calculation of the sample size: No calculation since it was based on the data from the national grid. Drawing of samples Following the nationally designed grid of points for monitoring, which consist of a grid of points distant to 4km, all points contained within the limit of the program are selected. There are in total 4308 sampling points, and all of them surveyed.



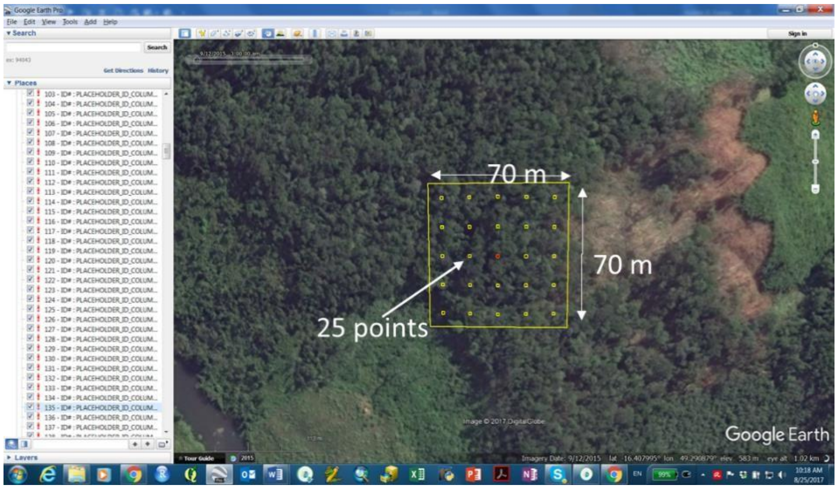
Location of sampling units

Response design

Spatial assessment unit:

The spatial assessment unit is a squared area of 70 meter of side which contains 25 points inside and which is centered on the random point selected from the sampling frame. Considering the acceptable geolocation error of Landsat imagery is 30 metres, this spatial assessment unit would be justified.

However, in terms of spatial support the information beyond the limits of the plot were used to assess whether one object within the assessment unit would comply with the minimum mapping unit.



Assessment or sampling unit

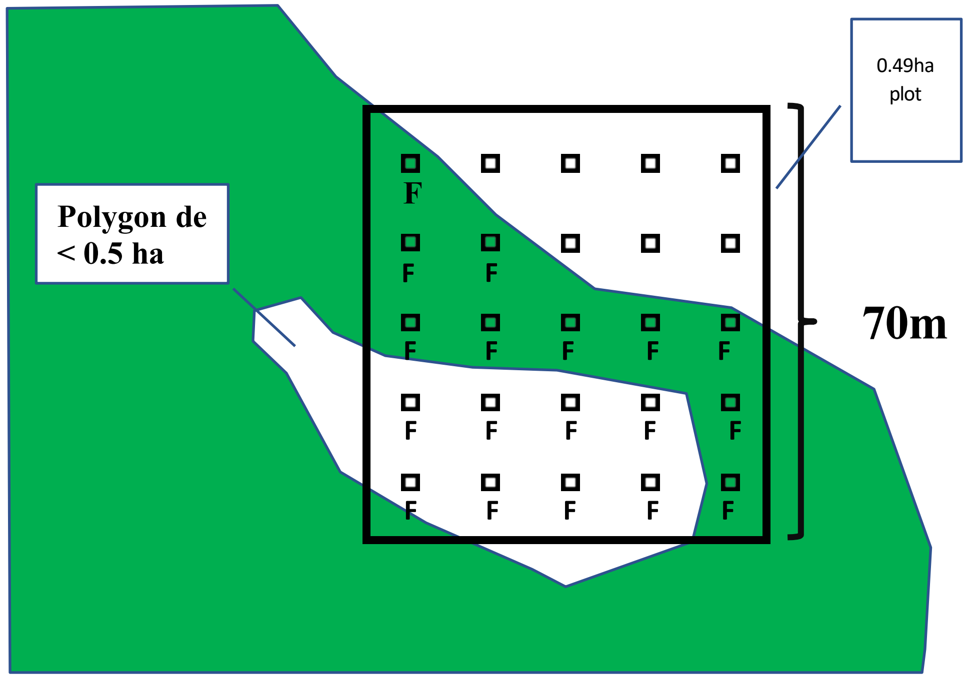
Source of the reference data:
The reference data in this case was collected through visual interpretation of all satellite imagery available to the country. This includes:

- Google Earth and Bing: All high and very high-resolution imagery accessible through Google Earth and Bing. The spatial coverage of very high-resolution imagery in the ER program area is relatively high, with many areas with coverage from 2005 to 2018.
- Aster: Resolution of 15 meters from 2000 to 2009
- Landsat 5 TM and 7 ETM+: Available through google earth engine.
- Landsat 8 OLI: Available through google earth engine for 2013-2017.
- Sentinel 2A MSI: Available through google earth engine for 2015-2017.

It is considered that these are reference data as most of the interpretations will be based on direct interpretation of higher resolution imagery for different periods which provides the necessary temporal and spatial contextual information.

Reference labelling protocol

- Forest/Non Forest classification: In order to attribute the sample to forest class, the interpreter would evaluate how many points of the grid would fall inside a forest (a differentiated object that has at least 0,5 ha in area and has 30% of tree canopy cover). If at least 13 points (>50% of points) fall in forest, the point would be classified as forest, otherwise it is classified as non forest. This method ensures that there is no overrepresentation of forest, which happens with hierarchical classification systems. In the following example, 8 points are situated in an area of the polygon that does not have trees, this polygon is less than 0.5 hectare which is part of a bigger forested polygon with area more than 0.5ha. In this case, the sampling unit is labelled as forest class.



Example of interpretation of sampling unit

- Forest types: If the sample is classified as forest, the sample would then be attributed to one of the 5 forest types based on the majority class present:
    - Primary forest
    - Modified Natural forest - Disturbed forest
    - Modified Natural forest - Agroforestry
    - Modified Natural forest - Secondary forest
    - Plantation - Plantation for wood
- Interpretation has been based on a protocol which can be found in the website of BNCCREDD+ (https://drive.google.com/file/d/1Hs3BSGL69kK6_ELrvq5h5-_I0pDZtJTS/view?usp=sharing)

Quality Control, Quality Assurance (QA/QC)

To ensure the quality of activity data, rigorous quality controls are carried out during data collection. Quality control and assurance is carried out in several layers to be robust and dependable, and that the quality of the resulting data is optimal and that the data itself contains the least possible error. The process is illustrated by the following figure:

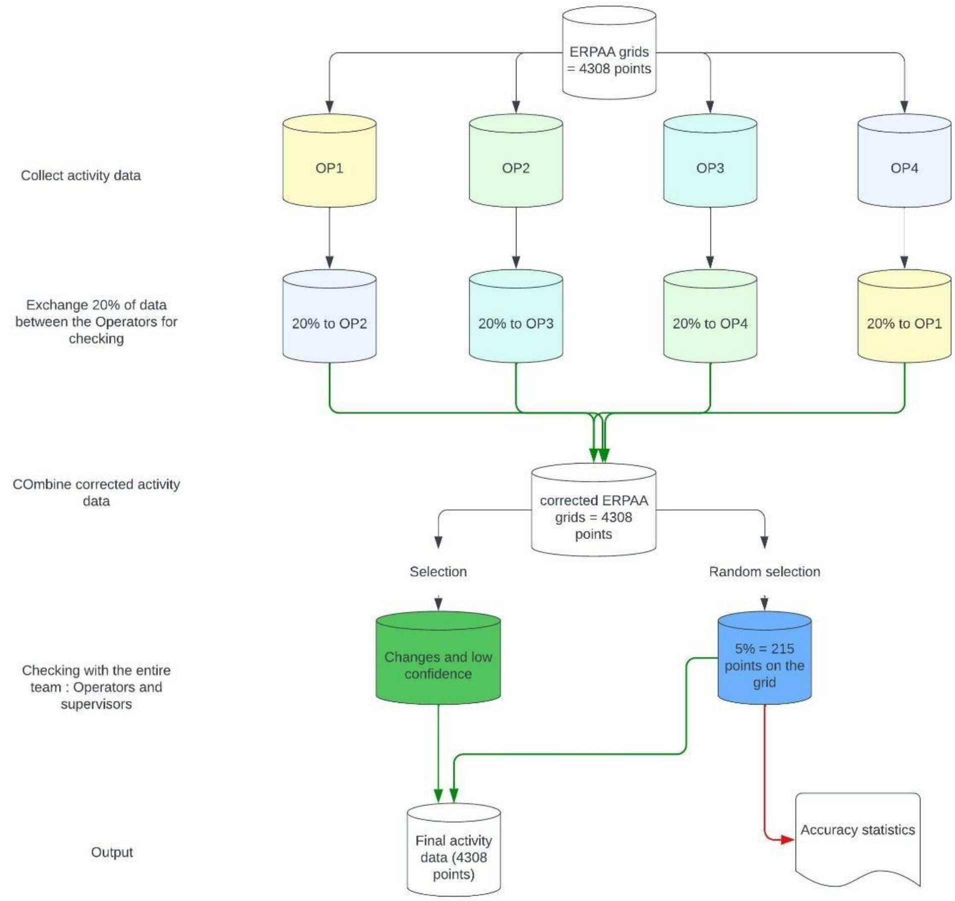


Figure 2: Activity data collection and quality control

- During data collection, operators strictly follow the data collection standard operating procedure
- In the event of ambiguity in the assignment of classes, operators seek advice from their colleagues, and if the doubt persists, mark the recording as low confidence (accuracy = NO) to be able to come back to it later with the whole team
- Once all the points have been collected, a first verification or correction is carried out: each operator checks 20% of the collections made by one of his colleagues. There are no error statistics for this first evaluation, but detected inconsistencies will be corrected immediately.
- After the 20% of exchanges, a random selection of 5% of all the data is made (215 records). Points are double-checked with the whole team: all operators and supervisors. This part evaluates the accuracy and quality of the data by comparing the data before and after verification. We could thus see the proportion of records that have undergone modifications or corrections, but in the exercise, we were more interested in records that affect emissions, so these are the land use change classes. The result of the comparison in the form of a confusion matrix is presented in Table 4. There were therefore initially 12 deforestation records, to finally, after modification and control by the entire team, there were only 10 records. Most of these modifications were the result of the modification of the dates of the changes which were initially in the window 2006-2015 but after verification, the change took place during other dates (in general after 2015).

Confusion matrix showing changes to activity data

(5% samples). C = Agriculture, F = Forest, G = Savannah, O = Bare soil, S = Artificial surface, W = Water. In red the changes in land use

		Corrected							
		CC	FF	FG	GG	OO	SS	WW	Total
Original	CC	14	0	0	0	0	0	0	14
	FF	0	77	0	0	0	0	0	77
	FG	0	1	10	1	0	0	0	12
	GG	0	0	0		0	0	0	
	OO	0	0	0	0		0	0	
	SS	0	0	0	0	0		0	
	WW	0	0	0	0	0	0		
	Total	14	78	10					

- To understand the omissions and additions of the different classes, Table 2 summarizes the errors in percentage: 17% commission error and 0% omission error. The commission error is statistically high, but understandable and rather necessary for the rest of the processing so that we have the possibility of capturing all the changes. Note that the errors for the other classes are always very low or zero.

Evaluation of omission and commission errors based on 5% random samples

Class ID	Class	Comission error	Omission error
CC	Stable crop	0.00	0.00
FF	Stable forest	0.00	0.01
FG	**Forest loss**	**0.17**	**0.00**
GG	Stable Grassland	0.00	0.01
OO	Stable bare soil	0.00	0.00
SS	Stable Artificial	0.00	0.00
WW	Stable water	0.00	0.00

- For the evaluation of the analysts' performance, each observation is also checked against the analyst who made the data collection (Table 3). The operators were precise in the analysis and the correction rate per operator is less than 2%

Operator performance based on 5% random data

n#	Operator	Assigned points	Correct	Changed	Proportion changed
1	Baovola	49	49	0	0.00
2	Johary	67	67	0	0.00

3	Sitraka	50	49	1	0.02
4	Topaniaina	49	48	1	0.02

- Now, to have full assurance that the results are correct, 100% of the change classes (deforestation, degradation, gain) as well as the records identified with low confidence (marked accuracy = NO) are checked one by one in the presence of the whole team. This process concerns 328 observations. After verification and possible correction of possible errors on the 328 observations of classes of change and low precision, it is no longer possible to have over-evaluation of emissions, on the other hand, one could always have omissions, since one evaluates the reference level, we therefore underestimate the emissions, and our assessment would be more conservative. The number of deforestation observations before was 158, and after the verifications, we had 147 deforestation records. We note initial recordings of deforestation which are changed to stable forest (FF 16 units), and to stable savannah (GG, 8 units), these are commission errors which are therefore corrected.

Confusion matrix after final checking

C = Agriculture, F = Forest, G = Savannah, O = Bare soil, S = Artificial surface, W = Water.

		Corrected								
		CC	**FF**	**FG**	**GF**	**GG**	**OO**	**SS**	**WW**	**Total**
Original	**CC**	14	0	0	0	0	0	0	0	**14**
	FF	0	183	3	1	1	0	0	0	**188**
	FG	0	16	134	0	7	0	0	0	**157**
	GF	0	0	0	5	0	0	0	0	**5**
	GG	0	5	12	3	152	0	0	0	**172**
	OO	0	0	0	0	0	1	0	0	**1**
	SS	0	0	0	0	0	0	2	0	**2**
	WW	0	0	0	0	0	0	0	4	**4**
	Total	**14**	**204**	**149**	**9**	**160**	**1**	**2**	**4**	**543**

In terms of percentage, we had 15% commission error for deforestation and 0% commission for gain; on the other hand, there is 10% omission error for deforestation and 44% omission for gains (Table 4). It is always important to note that these errors were all corrected during quality control sessions.

Error of commission and omission for all rechecked points

(543 records in total) **Class ID**	**Class**	**Comission error**	**Omission error**
CC	Stable crop	0.00	0.00
FF	Stable forest	0.03	0.10
FG	**Forest loss**	**0.15**	**0.10**
GF	**Forest gain**	**0.00**	**0.44**
GG	Stable Grassland	0.12	0.05

OO	Stable bare soil	0.00	0.00
SS	Stable Artificial	0.00	0.00
WW	Stable water	0.00	0.00

The results of the interpretation are the following:

Analysis design

The average proportion of the variable of interest in the reference period will be estimated through the simple random estimator of the mean.

In order to convert the proportions to areas, the average proportion is multiplied by the total area of the region of interest of 6,913,969 ha.

Estimate of proportions per class

Activity	Type	Stratified estimate (proportion)	Area estimate (ha)
Deforestation	Dense humid forest	0.004	27,241
	Degraded humid foret	0.032	223,045
	Secondary forest	0.00023	1,590
	Agroforestry	0.00023	1,590
	Plantations	0.0000	0
Enhancement	Secondary forest	0.001	8,020
	Agroforestry	0.0000	0
	Plantations	0.0000	0
Degradation	PF to Disturbed forest	0.017	117,123
	PF to Agroforestry	0.0000	0
	PF to Plantations	0.0000	0
	DF to Agroforestry	0.0000	0
	DF to Plantations	0.0000	0

In order to express the proportion of deforestation or afforestation/reforestation in annual basis, the sample estimate is divided by the duration of the reference period (i.e. 10 years).

Estimate of activity data per class

Activity	Type	Area (ha/year)
Deforestation	Dense humid forest	2,724.10
	Degraded humid forest	22,304.46
	Secondary forest	159.02
	Agroforestry	159.02
	Plantations	0
Degradation	PF to Disturbed forest	11,712.26
	PF to Agroforestry	0
	PF to Plantations	0
	DF to Agroforestry	0
	DF to Plantations	0
Enhancement	Secondary forest	802.02
	Agroforestry	0
	Plantations	0

More information is provided in the spreadsheet (cf file in this link) :

https://docs.google.com/spreadsheets/d/1AVdX-zztRiVPYi7yPNhHgmdyLCizrscq/edit?usp=drive_link&ouid=114519974924085988913&rtpof=true&sd=true

Value applied :

Activity	**Type**	**Area (ha/year)**
Deforestation	Dense humid forest	2,724.10
	Degraded humid forest	22,304.46
	Secondary forest	159.02
	Agroforestry	159.02
	Plantations	0
Degradation	PF to Disturbed forest	11,712.26
	PF to Agroforestry	0
	PF to Plantations	0
	DF to Agroforestry	0
	DF to Plantations	0
Enhancement	Secondary forest	802.02
	Agroforestry	0
	Plantations	0

<table>
<tr>
<td>QA/QC procedures applied :</td>
<td>

QC procedures in this case consist in the establishment of a Standard Operating Procedure (SOP) for the interpretation of the samples and the capacity building and of training of each person taking part in the process in order to ensure the correct implementation of SOPs. The SOPs designed prior to the data collection may be found in the link: https://drive.google.com/file/d/1Qf4PIgjvx03clSYtpbhC9_HboXIRP1go/view?usp=sharing
The forms in Collect Earth were also designed to implement validation rules that would avoid any consistency errors. Since validation rules could not avoid all possible inconsistency errors, the results of sampling units collected by an interpreter were reviewed by a different interpreter to check for inconsistencies.
Expert interpreters were used, sufficiently trained, with a specific SOP for interpretation.
Moreover, the interpreters indicate whether the quality of interpretation is high or low, so this serves to filter out those points that are of low quality in the interpretation. All sampling units labelled as low-confidence are re-assessed by an expert interpreter.
When collecting activity data in the Collect Earth tool: In general, once you fill in the information on a plot, you should do the verification of the information collected included. To see especially if the change of cover assigned and the classes of the two dates studied are logical. The result should match. An operator other than the one who performed the data collection retests a random sample of 20 percent of the total number of samples during Quality Assurance. For quality control, 5% of the total sample and all change classes and those with low confidence are reanalyzed by the group (https://drive.google.com/file/d/1Qf4PIgjvx03clSYtpbhC9_HboXIRP1go/view?usp=sharing).
During data analysis: The Laboratory and Methodology Manager, in coordination with the analysts, check that the calculations comply with SOP4 on data analysis, including the script used for the calculations. Then they cross-check the estimates with previously reported estimates for the same classes. Estimates are further cross-checked and compared with estimates reported by other sources (e.g. Global Forest Resources Assessment, National Greenhouse Gas Inventory, UNFCCC reports, Global Forest Watch…) (https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing).

</td>
</tr>
<tr>
<td>Uncertainty associated with this parameter:</td>
<td>
<table>
<tr><th>Activity</th><th>Type</th><th>Standard error (proportion)</th><th>90% confidence – Relative margin of error</th></tr>
<tr><td rowspan="5">Deforestation</td><td>Dense humid forest</td><td>0.001</td><td>40%</td></tr>
<tr><td>Degraded humid forest</td><td>0.003</td><td>14%</td></tr>
<tr><td>Secondary forest</td><td>0.00023</td><td>165%</td></tr>
<tr><td>Agroforestry</td><td>0.00023</td><td>165%</td></tr>
<tr><td>Plantations</td><td>-</td><td></td></tr>
<tr><td rowspan="3">Enhancement</td><td>Secondary forest</td><td>0.001</td><td>72%</td></tr>
<tr><td>Agroforestry</td><td>-</td><td></td></tr>
<tr><td>Plantations</td><td>-</td><td></td></tr>
<tr><td>Degradation</td><td>PF to Disturbed forest</td><td>0.002</td><td>19%</td></tr>
</table>
</td>
</tr>
</table>

		PF to Agroforestry	
		PF to Plantations	-
		DF to Agroforestry	-
		DF to Plantations	-
Any comment:			

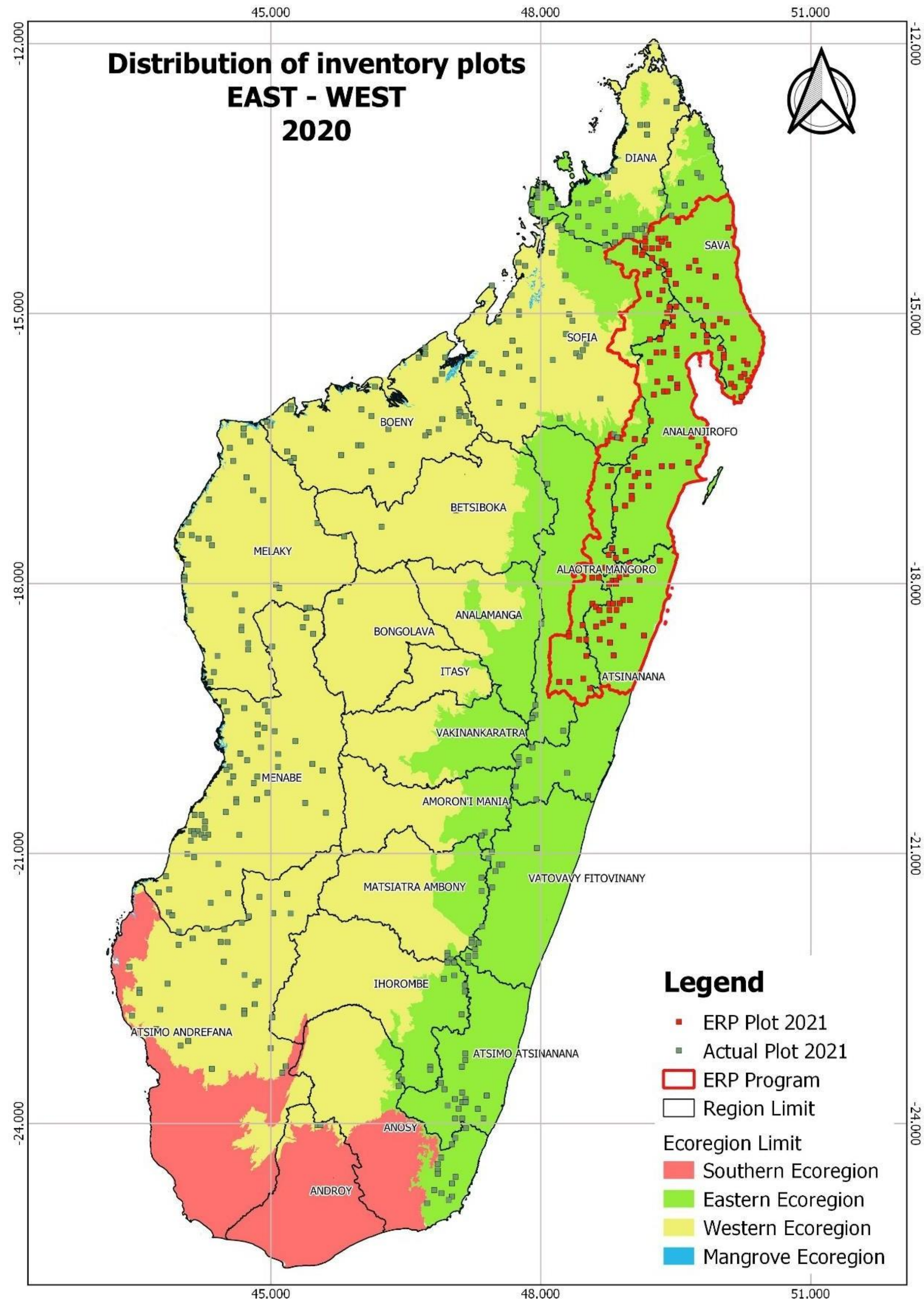
Parameter:	$AGB_{Before,j}$ $AGB_{After,j}$ $AGB_{Before,j}$ $AGB_{After,j}$ - (For Forest)
Description:	Aboveground biomass of forest type j before conversion, in ton of dry matter per ha; Aboveground biomass of forest type i after conversion, in tons dry matter per ha; Aboveground biomass of forest type j before conversion, in tons of dry matter per ha; Aboveground biomass of forest type i after conversion, in tonnes dry matter per ha;

Data unit:	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):	Data came from three main sources: • PERR-FH inventory, 2014: As part of the PERR-FH project, intact forests were measured in 2014 using a total of 189 plots located within the Ecoregion of the Eastern Humid Forests. • DVRF inventory, 2016: Since the national inventory did not cover secondary formations, an inventory was conducted in 2016 by DVRF targeting the following secondary forests: Agroforestry; Ravenala mixte; Ravenala; Single layer; and Savoka vieux. A total of 262 plots were measured. From all these formations, the single layer represents a more mature formation, which usually is the result of degradation of primary forest or old secondary forest. In this case, plots were located close to the forest boundary around 100-150 metres in distance. The other formations are secondary formations generally created after slash of primary forest. These formations have a similar stock of aboveground biomass, so Ravenala, Ravenala mixte and Savoka vieux has been decided to be merged into the secondary forest class. • DRGPF inventory, 2020: this inventory concerns all the forests in the eastern areas of Madagascar. This is the updating of inventory data according to the national 4kmx4km grid. 272 plots were inventoried. Three classes were considered: dense humid forest, degraded humid forest and secondary forest. Estimates of AGB according to inventory DRGPF, 2020

Stratum	AGB (tdm/ha)	Relative margin of error at 90% of confidence level
Dense humid forest	202.63	7%
Degraded humid forest	186.00	11%
Secondary forest	91.11	30%

Distribution of forest inventory plots

The following sections include a description on how these data were processed and the above values were derived.



The following sections include a description on how these data were processed and the above values were derived.

A/ Processing Workflow

Inventory data was processed as follows.
Inventory data processing workflow

Inventory raw data

↓

Calculation of tree height based on diameter – height function

↓

Assigning of WD for each tree

↓

Calculation of above ground biomass at tree level

↓

Assigning of a scaling factor (to 1 ha) for each tree based on plot radius

↓

Calculation of plot level above ground biomass at 1 ha scale

↓

Calculation of inventory statistics

Inventory data used to calculate aboveground biomass was selected as follows:

- (Woody) trees of dbh ≥ 5 cm;
- All of the Palm (*Ravenala madagascariensis* and *Dypsis sp*.).

B/ Height calculation

Allometric equations used to calculate tree biomass usually have as variable the height (total height in the case of trees, total height or trunk height in the case of the palms). During the 2020 inventory, all tree heights has been measured.

A formula for calculation of heights presented was developed to be used in the future where there is no possibility to make the height measurement in the field.

The tree height measured in the field was used to develop a height-diameter relationship based on a function proposed by Chave et al. (2014). According to the field stratum, several height-diameter relations have been established. The table below shows the relations that were developed, the corresponding stratum, the number of trees used to build this relation, as well as the relative error.

For the special case of the Palm, specific relationships were also established in order to complete the data in the rare case where the height could not be measured:

- Either to measure the total height (in the case of the *Ravenala madagascariensis*), from the height of the trunk or from diameter at height of collar (DHC) depending on available data
- Or to measure the height of the trunk (in the case of the *Dypsis sp*.), from the total height.

Relations used for calculating heights

STRATA	N°	EQUATION	NUMBER OF TREES	BIAS /ERROR
Primary Forests –PERR-FH 2014 Inventory	1	$\ln(H) = -0.07511*\ln(D)^2 + 0.988*\ln(D) + 0.267$	1,270	N/A
« Savoka vieux » or « Agroforestry » strata of the 2016 inventory	2	$\ln(H) = -0.0709*\ln(D)^2 + 0.9257*\ln(D) + 0.371$	1,365	N/A
« Mix Ravenala » strata of the 2016 inventory	3	$\ln(H) = -0.106*\ln(D)^2 + 1.1305*\ln(D) + 0.0097$	499	N/A
Palm: Dypsis sp.	4	$H_{stip} = 0.3772*H + 1.7639$	25	N/A
Palm: Ravenala madagascariensis	5	$\ln(H) = -0.0699*\ln(DHC)^2 + 0.9956*\ln(DHC) - 0.8902$	1,010	N/A
	6	$H = 0.9391*H_{stip} + 5.7537$	493	N/A
Humide Forest DRGPF 2020 Inventory	7	H = 0.0362 (D)2 + 1.0742 D +4.86	18,959	N/A
Humid forest (Chave et al. 2014)		$H = 1.389026 \times \exp(0.980517 \times \ln(D)) * \exp(-0.07032031 \times (\ln(D))^2)$	2519	16%
Humid forest (Vieilledent et al 2012)		$\ln(H) = 1.010 + 0.547 * \ln(D) + Error$	250	+4.7 meter

Where:

H: total height, in m

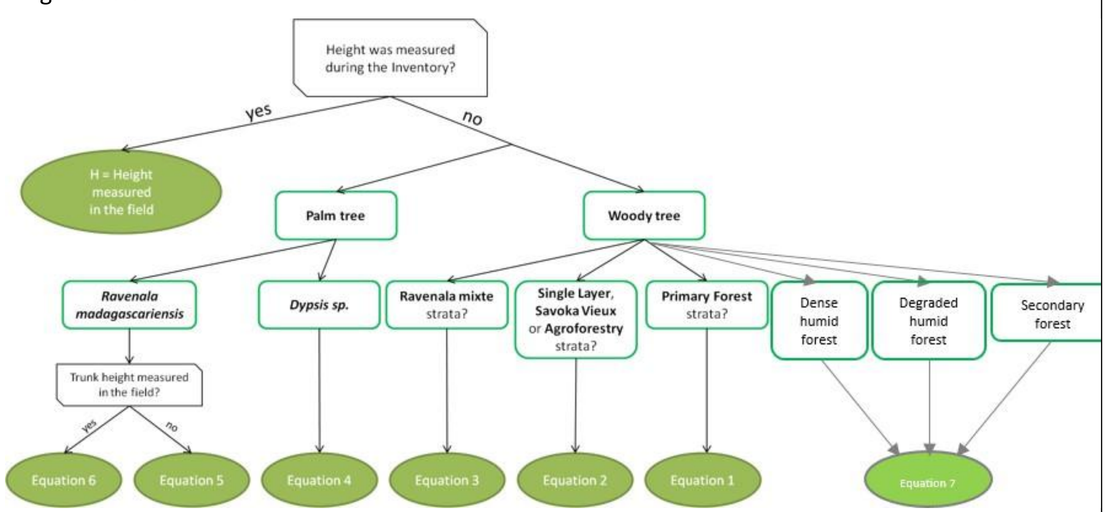
D: diameter at breast height, in cm

DHC: diameter at collar height (Palm trees) in cm

H_{stip}: height of the trunk (Palm trees), in m

Later in the calculations, this calculated height by tree has been used only for trees which were not measured in height on the ground: in other cases, it is the measured height that was used.

The choice of the relation to be used to calculate the height is illustrated by the decision tree shown in Figure below.

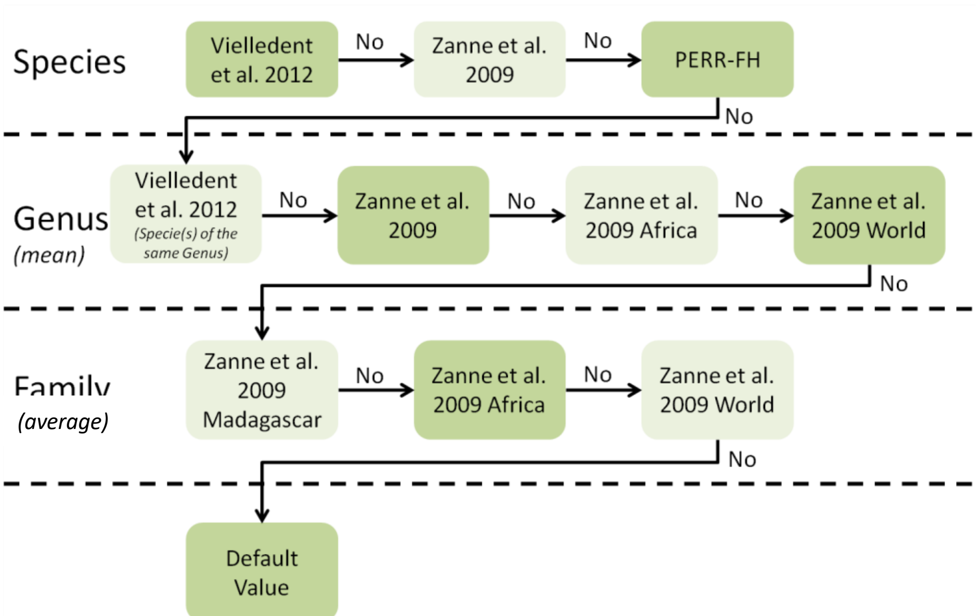


Decision tree to calculate height

C/ Wood density assignation

For the assessment of site/species biomass, the search for species, genus and family level densities was paramount. For this, the databases of Vielledent et al (2012), Zane et al (2009), Zane et al (2009) Madagascar, Perr-FH and LRA (2021) were used.

The figure below was followed when searching for specific densities.



Decision tree for assigning WD

Wood densities were assigned based on the following 3 main databases:

1. A wood density database compiled by Vielliedent et al. (2012) for research related to allometric equations
2. The global wood density database compiled by Zanne et al. 2009
3. The PERR-FH wood density database compiled by the PERR-FH project for the purpose of the PERR-FH inventory

In the order of the above appearance, these 3 databases were searched for a WD value at the species level. If no WD value was found or only the genus of the tree was known, then WD values were assigned based on the genus in the following order of priority:

1. WD value from a species of the same genus from the database of Vieilledent et al. (2012)
2. Mean WD across the genus for species found in Madagascar from the database of Zanne et al. 2009
3. Mean WD across the genus for species found in Africa from the database of Zanne et al. 2009
4. Mean WD across the genus from the entire database of Zanne et al. 2009

In cases where only a single species of the same genus was found, the WD of this species was assigned.

If no WD value was available at the genus level or only the family of the tree was known, then WD values were assigned based on the family in the following priority order:

1. Mean WD across the family for species found in Madagascar from the database of Zanne et al. 2009
2. Mean WD across the family for species found in Africa from the database of Zanne et al. 2009
3. Mean WD across the family from the entire database of Zanne et al. 2009

Finally, if no wood density could be assigned through the above process either because no WD data was unavailable or the tree could not be identified then a conservative WD default value of 0.5 was assigned (this value was chosen because it corresponds to the default value used in the PERR-FH project).

D/ Calculation of AGB at tree level

The tree level biomass was calculated based on the following allometric equation. Allometric equations used to calculate ground biomass

STRATA OR SPECIES		EQUATION	SOURCE
Trees (woody)	Humid forests (DRGPF 2020, inventory)	$\ln(AGB_{est}) = -1.103+1.994*LN(D)+0.317*LN(H_{tot})+1.303*LN(\rho)$	Vieilledent et al. (2012)
	Primary forests (PERR-FH 2014 inventory), modified forests ('Old Savoka' or 'Agroforestry' strata of the 2016 Inventory)	$\ln(AGB_{est}) = -1.948+1.969*LN(D)+0.66*LN(H_{tot})+0.828*LN(\rho)$	Vieilledent et al. (2012)
	(woody) trees of modified forests (« Ravenala mixte » strata of the inventory)	$\ln(AGB_{est}) = -1.56 + 1.912*\ln(D) + 0.471*\ln(H_{tot}) + 0.732*\ln(\rho)$	Randrianasolo et al., 2017
Palms	*Ravenala madagascariensis*	$\ln(AGB_{est}) = -5.08 + 5.654*\ln(H_{tot}) - 0.772*\ln(H_{tot})^2$	Randrianasolo et al., 2017

	Dypsis sp.	By default, the allometric equation that has been used is that of the *Chrysophylla sp* species as this was the equation which gave better results: $AGB_{est} = 0.182 + 0.498 * H_{stip} + 0.049 * H_{stip}^2$ Olofsson et al. (2014)	IPCC 2003 LULUCF GPG, Annex 4A.2 (Delaney et al. 1998 ; Brown et al. 1999)

With:

AGB_{est}: Estimated *Above-Ground Biomass* in tdm

ρ: Wood density

D: Diameter at Breast Height (DBH), in m

H_{tot}: Total height of the tree or palm (for the palm, including fronds)

H_{stip}: Height of the trunk (stem height of the Palm, without considering the fronds)

E/ Calculation of AGB at plot level

A scaling factor was applied to scale the values calculated at the individual tree level to 1ha. Since each plot consists of 04 subplots, different scaling factors were assigned based on the DBH of each tree. Table 5 shows the scaling factors for the fixed-size subplots.

Plots description

				DBH [cm] Ecoregion	
				Est	Ouest
Small trees	10	100	100	5 <DBH≤15	5< DBH ≤10
Medium trees	20	400	25	15< DBH ≤30	10< DBH≤20
Large trees	50	2,500	4	>=30	>=20
Regenerations	(1*1)*4	4	2,500	<5	<5

DBH (cm), total height (m), dead tree quality were recorded.

F/ Inference

	Arithmetic mean Sampling does not give real values. The results of the sampling are always estimates of the total population studied. Therefore, the average was calculated using the following formula. $$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$ (13) Where y_i is the parameter value for the i^{th} sample and n is the total number of samples collected. Arithmetique mean computation was automated in an Excel worksheet. The average was used to estimate the average value of total height, bole height and diameter at breast height at 1.30m from the ground. The analysis of the value of land area, volume and biomass was also done by calculating the arithmetic mean. Finally, it was used to know the general trend of the standing trees or the formation in general in the areas of inventories. Estimates of above-ground biomass per forest type

Forest type	**AGB (tdm/ha)**	**Number of samples**
Dense humid forest	202.63	155
Degraded humid forest	186.00	85
Secondary forest	91.11	21

Value applied:

Forest type	**Estimate (tdm/ha)**
Dense Humid forest	202.63
Degraded humid forest	186.00
Secondary Forest	91.11
Agroforestry	87.87
Plantation	29.55

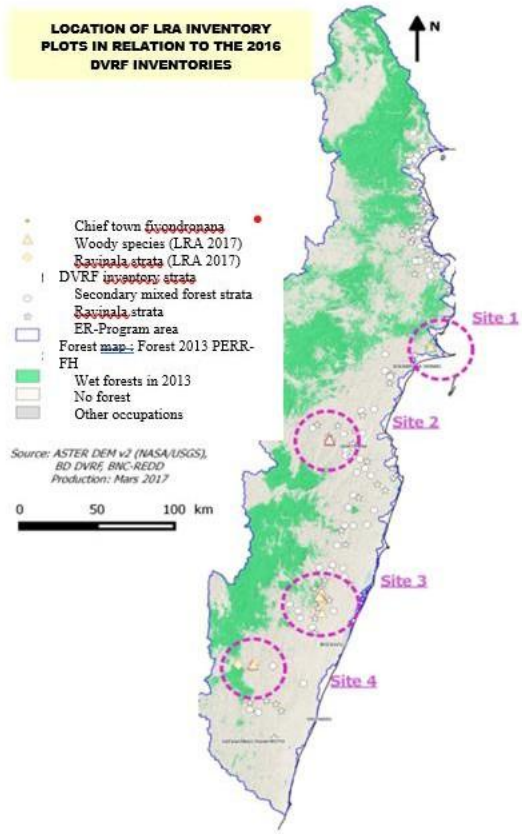
QA/QC procedures applied	During data collection, a team of supervisor spot checked 5% of the plots (DRGPF, 2021). The team went in the field and randomly chose surveyed plot, demanded the team to remeasure everything while the quality control team observe to see if they follow the SOP and parameters are measured correctly and data are recorded in the correct format that permit infallible retrieving later.
	Data processing were checked regularly and at every step by the Methodology unit at BNCCR with team of experts working with them.

Uncertainty associated with this parame

Class	**BA (tdm/ha)**	**Stdev**	**Number of samples**	**SE**	**Relative margin of error at 90%**
Dense Humid forest	202.63	99.59	155	8.00	7%
Degraded humid forest	186.00	111.90	85	12.14	11%

ter:	Secondary Forest	91.11	72.79	21	15.88	30%
	Agroforestry	87.87	40.45	28	7.64	15%
	Plantation	29.55			6.25	35%
Any comment:						

Parameter:	$AGB_{After,i}$ $AGB_{Before,i}$ *(non-forest)*
Description :	Aboveground biomass of non-forest type j before conversion, in tonne of dry matter per ha Aboveground biomass of non-forest type i after conversion, in tonnes dry matter per ha;
Data unit:	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) :	This are sourced from a destructive sampling of Savoka Jeune secondary formations conducted as part of the Laboratoire de Recherches Appliqués in 2016-2017. These formations are the precursors of Savoka vieux, Ravenala mix and agroforestry formations. ***A/ Sampling design*** The samples were located in four different areas, located in the Centre and the South of the ER program area. These locations are part of the regions of Analanjirofo, Atsinanana and Alaotra Mangoro. Its general characteristics are the following: • Site 1 (Axe Soanierana Ivongo): centre of the ER program and below 200 m of altitude; • Site 2 (Axe Vavatenina): centre of the ER program and at least 400 m of altitude; ; • Site 3 (Axe Brickaville): south of the. ER program and below 400 m of altitude; • Site 4 (Axe Andasibe): south of the ER program and above 400 m of altitude.



Location of plots for estimation of biomass in non-forest

In each of the sites several 1 m^2 plot were established and they were established at different locations within watersheds in order to understand the impact of this in the aboveground biomass. Moreover, the plots within each of the slopes were located on Savoka jeune with different ages ranging from 4 to 10 years in order to understand the variability of Savoka Jeune with age. A total of 292 plots were established.

Number of sampling units per site for the estimation of biomass in Savouka Jeune

Topographic position	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**TOTAL**
C1 : low slope	19	27	21	22	292
C2 : mid-slope	23	26	24	24	
C3 : high slope	19	34	27	26	
TOTAL per site	61	87	72	72	292

B/ Measurement

Within these plots, a destructive measurement of herbaceous vegetation and woody vegetation was made. The samples were then taken to laboratory and the samples were dried at a

<table>
<tr><td></td><td>temperature of 70°C for the leaves and the herbaceous vegetation and 103°C for the shrubs until constant weight between 24-hour intervals. In general, the drying process has taken 3 days in the case of leaves and grasses, and the woody biomass has taken 5 days.

Picture of bags with destructive samples

The anhydrous mass of the shrubs and grasses has been measured with a balance with 0.01 g accuracy.

C/ Statistical analysis

Different statistical parameters was evaluated:

The average estimate of Aboveground Biomass is estimated through the random estimator of the mean ($\hat{\mu}$):

$$\hat{\mu} = \frac{1}{n}\sum_{k=1}^{n} y_k$$

Where:

- y_k is the k sample estimate given by the biomass estimated per plot as described above. This is the biomass per sampling unit estimated above.
- n is the number of samples
- For the all four sites, the biomass factor for Savoka jeunes is of 11.96 ±6.5 t/ha.
</td></tr>
<tr><td>Value applied:</td><td>11.96</td></tr>
<tr><td>QA/QC procedures applied:</td><td>Inventory quality control: technical supervision by DRGPF and BNCCREDD+ supervisors and strategic supervision by MEDD staff, verification of inventory sheets and databases.</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>The main uncertainty is the sampling uncertainty and the representativeness of the data. See Chapter 12.

The sampling error is estimated through the following formula.

$$\widehat{Standard\ error}(\hat{\mu}) = \frac{1}{\sqrt{n \times (n-1)}} \times \sum_{k=1}^{n}(y_k - \hat{\mu})^2$$

Where:</td></tr>
</table>

	• y_k is the k sample estimate given by the biomass estimated per plot as described above. This is the biomass per sampling unit estimated above; • $\hat{\mu}$ the random estimator of the mean; • n is the number of samples. The result is multiplied by the t-student value for the 90% confidence level in order to estimate the confidence interval. The margin of error is the half width of the confidence interval divided by the average estimate. Estimates of AGB in non-forest

Class	AGB (tdm/ha)	Stdev	Number of samples	SE	Relative margin of error at 90%
Non Forest	11.96		120	3.28	46%

Any comment:	

Parameter:	C_O (Old)
Description :	Dead wood/litter stock, under the old land-use category (before deforestation), tons C ha-1.
Data unit:	tC/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 same calculation procedures as the aboveground biomass were followed, but only with the trees that were labelled in the field as dead trees. This resulted in the following: Estimates of dead wood per forest type

Forest type	DW (tdm/ha)	Litter (tC/ha)
Dense humid forest	12.93	2.1
Degraded humid forest	12.13	
Secondary forest	10.61	
Agroforestry	10.88	

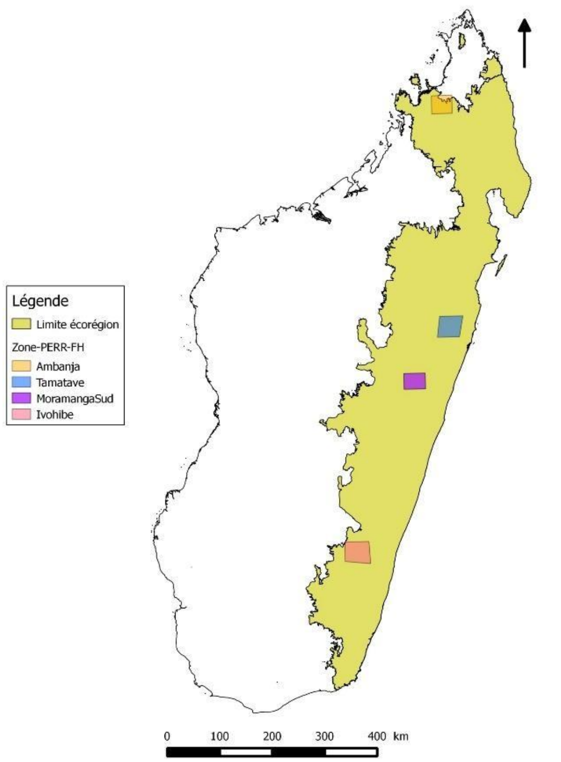
These values were then multiplied by 0.47 in order to provide the carbon stocks for the Dead wood.

Value applied:

Forest type	Value
Dense humid forest	12.93
Degraded humid forest	12.13
Secondary forest	10.61
Agroforestry	10.88

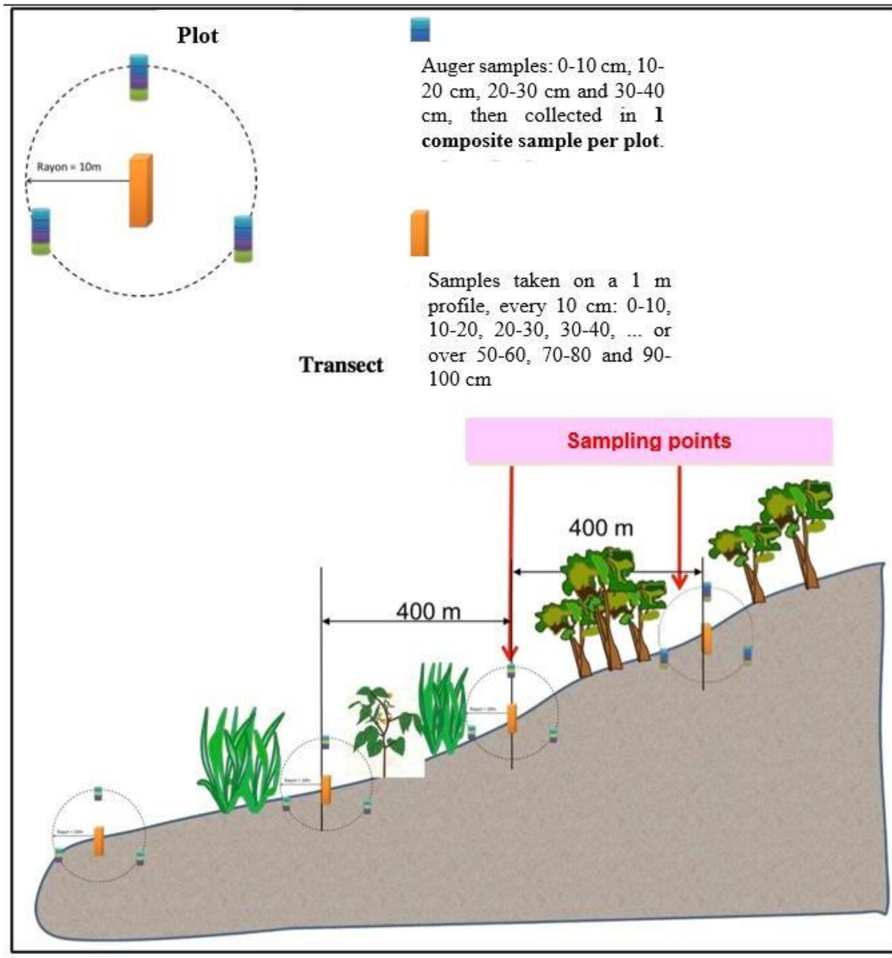
<table>
<tr><td>QA/QC procedures applied:</td><td>Inventory quality control: technical supervision by DRGPF and BNCCREDD+ supervisors and strategic supervision by MEDD staff, verification of inventory sheets and databases.</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>
<table>
<tr><th>Class</th><th>DW (tdm/ha)</th><th>SE</th><th>Relative margin of error at 90%</th></tr>
<tr><td>Dense humid forest</td><td>12.93</td><td>1.34</td><td>17%</td></tr>
<tr><td>Degraded humid forest</td><td>12.13</td><td>0.88</td><td>12%</td></tr>
<tr><td>Secondary forest</td><td>10.61</td><td>5.56</td><td>87%</td></tr>
<tr><td>Agroforestry</td><td>10.88</td><td>5.70</td><td>89%</td></tr>
</table>
</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

Parameter:	$SOC_{Before,j}$ $SOC_{After,i}$
Description :	Soil Organic Carbon at 30 cm depth of forest type j before conversion, in tonne of carbon per ha and Soil Organic Carbon at 30 cm depth of non-forest type j after conversion, in tonne of carbon per ha. SOC_{Before} corresponds to SOC of the forest and SOC_{After} corresponds to SOC of non forest
Data unit:	tC/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 of soil estimates are based on a specific inventory conducted in the Eastern Humid Ecoregion as part of the PERR-FH (https://redd.unfccc.int/files/20180528_frel_mada_modified.pdf) ***A/ Sampling plan*** The inventory consistent in sampling in four different regions within the ecoregion, where 5 different chrono sequences were established. 

Location of soil sampling units

The chronosequences was established to understand the changes in carbon stocks from Forests to the Tavy system, and to understand these changes across time as shown in the following figure.



View of the chrono sequences sampling for soil organic carbon
A total of 200 samples were collected, 75 in forest and 125 in non-forests, 50 in each of the four regions identified.

Sample size for the estimation of SOC

Class	Forest	Non-Forest	Total
Ambanja	26	24	50
Tamatave Est	22	28	50
Moramanga Sud	11	39	50
Ivohibe	16	34	50

Total	75	125	200

B/ Measurement H

Data was collected following best practice standards in soil measurement. This was done for the profile down to 30 cm of depth and 1 meter of depth. Once collected the samples, apparent density and carbon content are estimated.

The most commonly used method for calculating soil organic carbon stocks at equivalent volume is to measure C stocks for each layer and taking into account apparent density and coarse content (EG: stoniness) of the soil. . The calculation of carbon stock in mega grams of C per hectare (Mg C / ha, or tonne of C per hectare t C / ha) is done using the equation presented below:

$$SOC_i = DA \times 0{,}1 \times (1 - (EG/100)) \times C_{org} \times e$$

Where:

SOCi : Carbon stocks in depth i (i = 0-10 cm, 10-20 cm, 20-30 cm), en tC/ha;

DA : Aparent density, en g/cm3 ;

EG : Percentage of gross elements > 2 mm, in %;

Corg : Organic carbon content, en g C/kg ;

e : Depth of the horizon, in cm (ici e = 10 cm).

The SCO for depths of 0 to 30 cm (SCO_30) were obtained by summing the stocks calculated for each thickness (0-10cm, 10-20cm, 20-30cm) (PERR-FH. 2015)). The corrections necessary to take into account the presence of coarse elements have been applied; thus, the mineral fraction greater than 2 mm (EG), being supposed to be devoid of C was thus removed from the stock. In this sense, for the first 30 cm of soil, the volume equivalent stock is calculated with the following equation:

$$SCO\_30 = SCO_{0\text{-}10} + SCO_{10\text{-}20} + SCO_{20\text{-}30}$$

The link to the document showing this equation is :
https://drive.google.com/file/d/1BpIptFIdsQYvn8pWp4CqxCGADq95nvVT/view?usp=drive_link

Volume-equivalent C stocks have been used mainly for soil carbon mapping and modelling

C/ Inference

The soil organic carbon stocks are estimated and provided in the following table

Estimates of SOC for forest and non-forest according to PERR-FH

Class	**SOC (tdm/ha)**	**N**	**Standard deviation**
Forest	110.97	125	39.17
Non-Forest	104.65	75	37.53

	These estimates were then assigned to all classes including primary forest and modified natural forest.

Value applied:

Class	Value
Primary Forest (PF)	110.97
Modified Natural Forest - Disturbed Forest (DF)	110.97
Modified Natural Forest - Secondary forest (SF)	110.97
Modified Natural Forest - Agroforestry (DF)	110.97
Plantations - plantations for wood	0
Non-Forest	104.65

QA/QC procedures applied:

Uncertainty associated with this parameter:

The sampling error is provided below.

Estimates of SOC for forest and non-forest according to PERR-FH

Class	**90% level – confidence interval**
Forest	5%
Non-Forest	7%

Any comment:

3.2 Monitored Data and Parameters

Parameter :	$A'(j,i)_t, A'(i,j)_t$
Description :	• Annual conversion from forest type j (primary forest, modified natural forest), to non-Forest Land uses i (Non-Forest) in the monitoring period • Annual conversion from forest type j (primary forest), to forest type i (modified natural forest and plantations) in the monitoring period * Annual conversion from non-Forest Land use i to forest type j (planted forest or modified natural forest) in the monitoring period
Data unit :	ha/year

Value monitored during this Monitoring / Reporting Period:

Activity	Type	Area (ha/year)
	Dense humid forest	**1,392.62**
	Degraded humid forest	**19,356.10**
	Secondary forest	**0**
Deforestation [††]	Agroforestry	0

	Plantations	**0**
Degradation [§] [**]	PF to Disturbed forest	**7,916.10**
	PF to Agroforestry	0
	PF to Plantations	0
	DF to Agroforestry	0
	DF to Plantations	0
Enhancement [††]	Secondary forest	903.75
	Agroforestry	2,063.99
	Plantations	97.77

The method used to estimate gains or removals involved identifying, via Collect Earth, the conversion of the "non-forest" land cover class to "forest" between 2021 and 2024 ("Grassland" to "Forest"). Gains were not recorded for the two monitoring periods : 2020 (which is the first monitoring period beginning in March 2020) and 2021–2022 (which is the second monitoring period beginning on January 1, 2021), as the period would have been too short to detect changes in land cover class from "non-forest" to "forest." Thus, gains between 2021 and 2024 were accounted for on a cumulative basis only for the third monitoring period, 2023–2024. The total gains achieved were divided by two to obtain the annual gain (expressed in ha/year) for the 2023–2024 period, which made it possible to calculate the Program's total forest gains.

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

Sampling design: Due to the project area size, and the very small proportion of change (deforestation and gain), a stratified random estimates was chosen to the most appropriate sampling method.

Estimator:

Stratified random estimator of a proportion

Stratification:

A forest cover change map was created as stratification criteria. The initial target stratum was stable forest, stable non forest, forest loss, forest gain and a buffer around areas prone to errors (deforestation, gain, forest edges). Upon running the process, there were no gain identified so that was removed from the land use class, Also, errors can be minimized by post-stratifying the buffer into two depths : buffer from 50m from forest edge and a second buffer from 50m to 100m from forest edge. Water was part of the land use classification but not included in the stratum since no sampling points will be set in the water. More information on the methods for production of the maps is provided in the SOP on stratification map creation:

SOP0

* Stratification used for the activity data estimation

Strata

11- Forest

12- Deforestation

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† (refers to the file "deforestation_2023-2024" for deforestation datas monitoring 2023-2024)

‡ https://drive.google.com/file/d/1jsbTW6O7K1HKxhCfwF38ZJy_s3VU8D4P/view?usp=sharing (refers to the files on deforestation, degradation and gain: datas for the the FREL 2006-2015)

§ https://drive.google.com/drive/folders/1O2pUXfjUJ1s5_Cy83DrlfrXOIBqn0US7?usp=sharing (refers to the file "degradation_2023-2024" for degradation datas monitoring 2023-2024)

** https://drive.google.com/file/d/1jsbTW6O7K1HKxhCfwF38ZJy_s3VU8D4P/view?usp=sharing (refers to the files on deforestation, degradation and gain: datas for the the FREL 2006-2015)
†† https://drive.google.com/file/d/1jsbTW6O7K1HKxhCfwF38ZJy_s3VU8D4P/view?usp=sharing (refers to the files on deforestation, degradation and gain: datas for the the FREL 2006-2015)

22-Non-forest
55- Buffer Forest 50 m-100 m
56- Buffer Forest 0-50 m

Precision and confidence level:
Relative margin of error of 20% at 90% of confidence level as requested

Calculation of the sample size:
For the calculation of the sample size, the equation from Cochran (1977, Eq. (5.25)) was used assuming that the cost of sampling each stratum is the same :

$$n = \frac{(\sum W_h S_h)^2}{[S(\hat{O})]^2 + (1/N)\sum W_h S_h^2} \approx \left(\frac{\sum W_h S_h}{S(\hat{O})}\right)^2$$

Where:
W_h Weight of stratum *i*;
S_h Standard deviation of variable of interest in stratum i;
$(\hat{O})$ Standard error of the variable of interest.
N Number of sampling units in the region of interest (i.e., population size);

The sample size was estimated through an iterative approach and using proportion of total deforestation as the variable of interest:

- First of all, 300 sampling units were collected per stratum (Stratum 11, 22, 55 and 56) instead of stratum 12 where 150 were collected: this gives a total of 1,350 points.
- A calculation of the sample size was done, and as a result 3,026 additional samples were added in two strata : 2,381 samples for strata 22 and 645 for strata 56.
- The total number of samples analyzed was: 4,376.

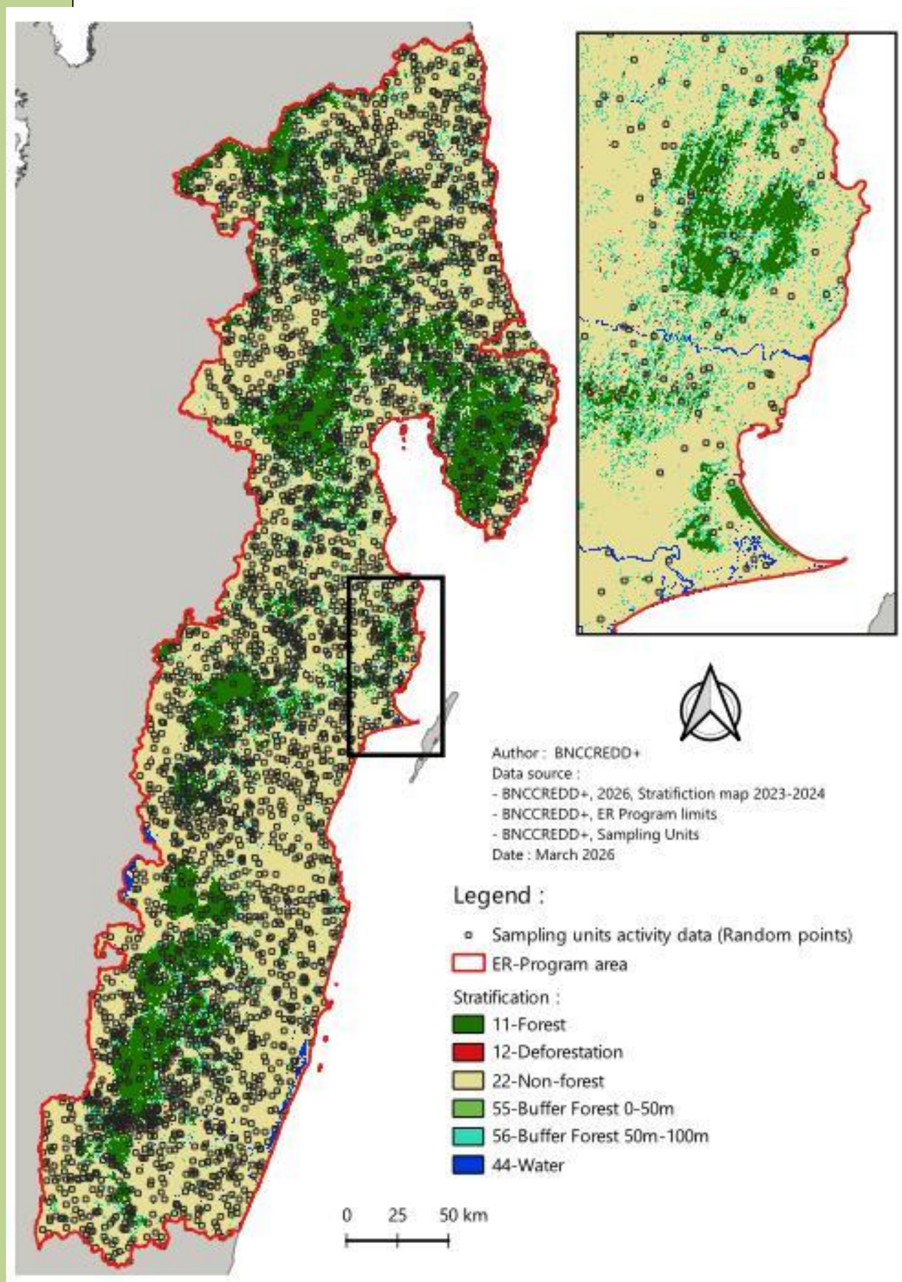
Sample allocation was based on an optimal approach. (Samples estimation seen at the web address: https://drive.google.com/drive/folders/1cthuW-oOS25C5AxRd5zVFauefCKP6jzL?usp=sharing

Calculation of number of samples per stratum for the second monitoring report‡‡

Code	Class	Weight of strata	Number of samples
11	Stable Forest	*0.18104656*	300
12	Deforestation	*0.004242485*	150
22	Stable Non Forest	*0.700883925*	2681

55	Buffer Forest 50m-100m	*0.034535986*	300
56	Buffer Forest0m-50m	*0.079291042*	945

‡‡ https://drive.google.com/drive/folders/1cthuW-oOS25C5AxRd5zVFauefCKP6jzL?usp=sharing (refers to the determination of the sample size)



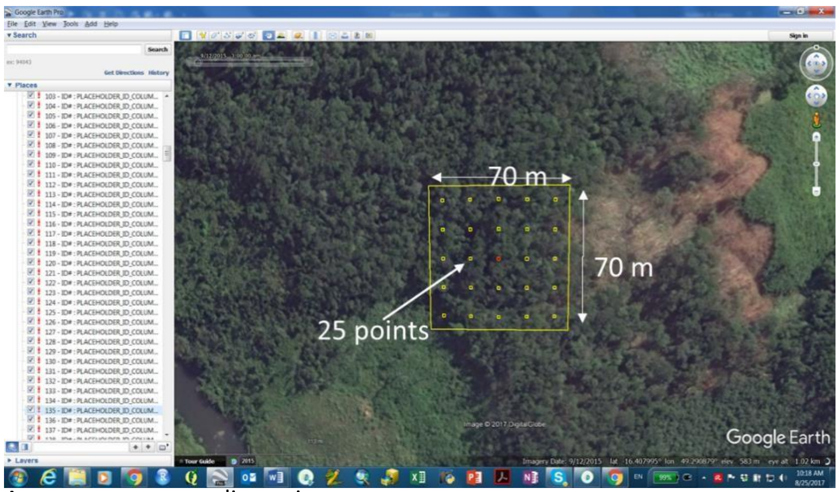
Location of sampling units and stratification

Response design

Spatial assessment unit:

The spatial assessment unit is a squared area of 70 meter of side which contains 25 points inside and which is centered on the random point selected from the sampling frame. Considering the acceptable geolocation error of Landsat imagery is 30 meters, this spatial assessment unit would be justified.y

However, in terms of spatial support the information beyond the limits of the plot were used to assess whether one object within the assessment unit would comply with the minimum mapping unit.



Assessment or sampling unit

The same sampling unit (square of 70 m x 70 m) was used for the data collection.

Data collection by interpreters:

Interpreters assess sample units, using the interpretation key as a guide to assess different land use classes and transitions. The interpreters consult each other and the Laboratory Manager if they have any doubts about the interpretation of the image.

The Laboratory Manager organizes a validation based on a set of samples evaluated by two or more interpreters.

During data collection, the Laboratory Manager encourages discussions and a group evaluation of the samples with all the interpreters for mutual validation and good calibration with a common understanding of the techniques by the group.

The Laboratory Manager notes challenges and limitations during data collection as well as potential sources of bias during data collection.

Data assembly:

Once data collection is complete, the Laboratory Manager compiles a data set which should include the following information:

• A database of sample data collected by interpreters including:

o Geographic coordinates defined in the coordinate or projection system

o The unique identification code for each sample unit o The interpretation of all sample units, including the previous interpretation(s) of the sample unit in case this has been revised or corrected.

- QA/QC: A number of QA/QC procedures have been applied:

Quality Assurance/Quality Control (QA/QC):
The interpreters reanalyze the individually collected data (taking a random percentage of samples (in our case, 20%)) by inverting the collection results. The results are then, if necessary, reanalyzed as a group during a series of sessions during which all samples with changes are reanalyzed. Samples with doubt are also closely reviewed. All of these samples must constitute 5 percent of the number of sample units.

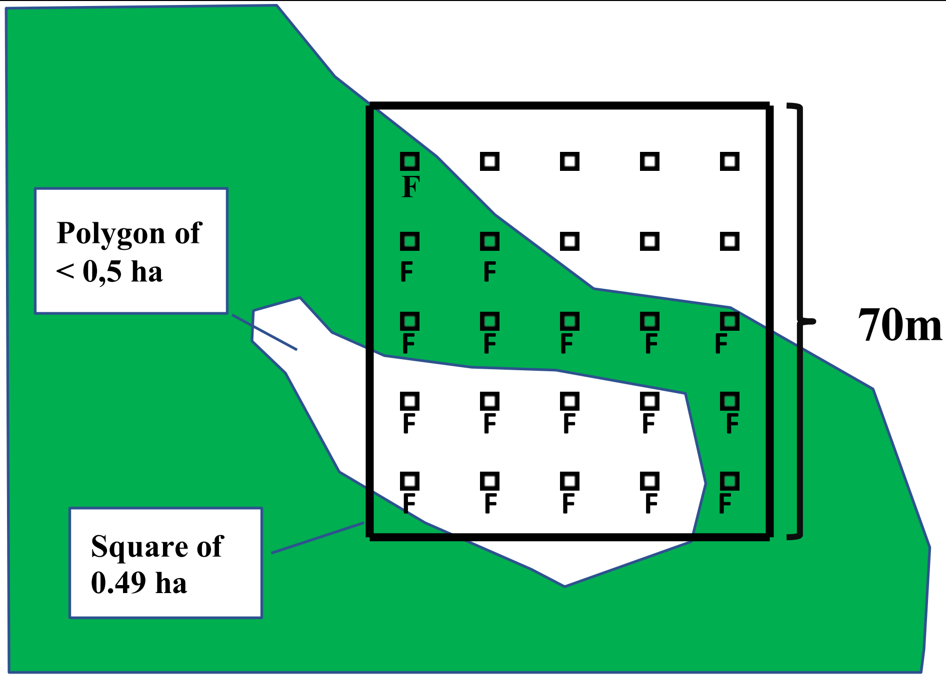
Source of data:
The data in this case was collected through visual interpretation of all satellite imagery available to the country:

- Google Earth with high and very high resolution imagery (2000 to 2025);
- Landsat 8 (year 2013 to 2024); Sentinel 2 (year 2015 to 2025).

It is considered that these are reference data as most of the interpretations will be based on direct interpretation of higher resolution imagery for different periods which provides the necessary temporal contextual information.

Reference labelling protocol

- Forest/Non-Forest classification: In order to attribute the condition of forest to the sample, the interpreter evaluated how many points of the grid would fall over forest (a differentiated object that has at least one ha in area and has 30% of tree canopy cover). If at least 13 points (>50% of points) fall in forest, the point would be classified as forest, otherwise as non-forest. This method ensures that there is not a overrepresentation of forest, which happens with hierarchical classification systems. In the example below, although only 10 points fall over canopy, 18 points fall in forest area, so the sampling unit is classified as forest.



Example of interpretation of sampling unit

- Forest types: If the sample is classified as forest, the sample would then by attributed to one of the 5 forest types based on the majority class present:
    - Primary forest
    - Modified Natural forest - Disturbed forest
    - Modified Natural forest - Agroforestry
    - Modified Natural forest - Secondary forest
    - Plantation - Plantation for wood
- Interpretation has been based on a protocol found in this link
- (https://drive.google.com/file/d/1f164QBw2W3mVzvgn7iOynA7SwmXcP6Mf/view?usp=sharing)

The results of the interpretation during the third monitoring report are the following:
Sampling units per strata

		Strata				
Activity[§§]	**Type**	**11**	**12**	**22**	**55**	**56**
Deforestation	Primary forest	5		1		
	Disturbed forest		78	5	5	18
	Secondary forest					
	Agroforestry					
	Plantations					
Enhancement	Secondary forest			1		

	Agroforestry			1		4
	Plantations		1			
Degradation	PF to Disturbed forest	2	2		6	4
	PF to Agroforestry					
	PF to Plantation					
Total number of sampling units		19	79	8	5	22
Total		133				

Verifications with ancillary data:
If external data exists, the Laboratory manager uses these external data sources (eg maps, etc.) to make a comparison with the classification of the sampling unit. Discrepancies between the two sets of data can be reported by the Laboratory Manager. Confirmed differences between the two datasets can be documented to show why sample-based area estimation may yield different results compared to other data sources.

Performance evaluation
By having the .csv data of the activity data and the stratification map in raster version, or the .csv table of the proportion of each stratum with the surfaces in number of pixels and in hectares, as well as the number of samples per stratum, a matrix of proportions is established. Analysts construct a matrix that shows strata (map classes) and reference classes. The matrix lists the numbers of sampling units and areas of the stratification map.

An error matrix is obtained which is recorded. Analysts then calculate stratum weights by dividing the area of each class or stratum by the total reporting area. We obtain a table on the area and the weight of the strata using an R script and we must retrieve the file area_stratum.csv, and calculate the weight of the stratum.

Analysis design
The average proportion of the variable of interest in the reference period will be estimated through the stratified random estimator of the mean ($\hat{\mu}_{STR}$)

$$\hat{\mu}_{STR} = \sum_{h}^{H} W_h \hat{\mu}_h$$

Where:
W_h Weight of stratum *h*;
$\hat{\mu}_h$ Sample estimates within stratum *h* which is equal to $\hat{\mu}_h = \frac{1}{n_h}\sum_{k=1}^{nh} y_{hk}$ where y_{hk} is the *i*th sample observation in the *h*th stratum
In order to convert the proportions to areas, the average proportion is multiplied by the total area of the region of interest of 6,913,969 ha.

§§ https://drive.google.com/drive/folders/1O2pUXfjUJ1s5_Cy83DrlfrXOIBqn0US7?usp=sharing

Estimate of proportions per class

Activity	Type	Stratified estimate (proportion)	Area estimate (ha)
Deforestation	Dense humid forest	0.000402	**2,785**
	Degraded humid forest	0.005599	**38,712**
	Secondary forest	0	**0**
	Agroforestry	0	0
	Plantations	0	**0**
Enhancement	Secondary forest	0.000261	**-1,807**
	Agroforestry	-0.000597	**-4,128**
	Plantations	-0.000028	**-196**
Degradation	PF to Disturbed forest	0.002289	**15,832**
	PF to Agroforestry	0	**0**
	PF to Plantations	0	0
	DF to Agroforestry	0	**0**
	DF to Plantations	0	**0**

The proportion of deforestation or afforestation/reforestation is expressed in an annual basis.

Estimate of activity data per class

Activity	Type	Area (ha/year)
Deforestation	Dense humid forest	**1,392.62**
	Degraded humid forest	**19,356.10**
	Secondary forest	**0**
	Agroforestry	0
	Plantations	**0**
Degradation	PF to Disturbed forest	**7,916.10**
	PF to Agroforestry	-
	PF to Plantations	-
	DF to Agroforestry	-
	DF to Plantations	-
Enhancement	Secondary forest	**903.75**
	Agroforestry	**2,063.99**
	Plantations	- **97.77**

<table>
<tr><td>QA/QC procedures applied:</td><td>QC procedures in this case consist in the establishment of a Standard Operating Procedure (SOP) for the interpretation of the samples and the application of training procedures in order to ensure the correct implementation of SOPs:
SOP2; SOP3

The labeling or assignment of a class to a sample is checked three times:
- A first time, by the analyst or interpreter who interprets the satellite images for the year or study period and on the basis of different sources (Landsat, Sentinel, Google Earth, etc.);
- During QA/QC: for quality assurance, a random 20 percent of the samples is checked by another analyst (exchanges of results files) who is taken at random according to the organization set by the Laboratory Manager; rectification is made in the event of an error of interpretation;
- During QA/QC: for quality control, samples with low confidence, samples with changes (deforestation, degradation and forest gain) are re-analyzed by the team concerned who form a discussion and validation committee for the output of the final result. The overall total retested should be at least 5 percent of the total number of samples. Rectification is made in the event of an error of interpretation. It is also important to pay attention to the following point during the interpretation: The distinction between deforestation and forest remaining burnt forest must imperatively be made by exploiting all the sources of information available from the archives of satellite images because it proves that a forest remaining forest that is burned, is not necessarily a land use conversion.</td></tr>
<tr><td>Uncertainty for this parameter:</td><td>
<table>
<tr><th>Activity</th><th>Type</th><th>Standard error (proportion)</th><th>90% confidence – Relative margin of error</th></tr>
<tr><td>Deforestation</td><td>Dense humid forest</td><td>0.000268</td><td>110%</td></tr>
<tr><td></td><td>Degraded humid forest</td><td>0.000748</td><td>22%</td></tr>
<tr><td></td><td>Secondary forest</td><td>0</td><td>0</td></tr>
<tr><td></td><td>Agroforestry</td><td>0</td><td>0</td></tr>
<tr><td></td><td>Plantations</td><td>0</td><td>0</td></tr>
<tr><td>Enhancement</td><td>Secondary forest</td><td>-0.000261</td><td>-164%</td></tr>
<tr><td></td><td>Agroforestry</td><td>-0.000310</td><td>-86%</td></tr>
<tr><td></td><td>Plantations</td><td>-0.000028</td><td>-164%</td></tr>
<tr><td>Degradation</td><td>PF to Disturbed forest</td><td>0.000911</td><td>65%</td></tr>
<tr><td></td><td>PF to Agroforestry</td><td>-</td><td>-</td></tr>
<tr><td></td><td>PF to Plantations</td><td>-</td><td>-</td></tr>
<tr><td></td><td>DF to Agroforestry</td><td>-</td><td>-</td></tr>
<tr><td></td><td>DF to Plantations</td><td>-</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>Any comment :</td><td></td></tr>
</table>

4. QUANTIFICATION OF EMISSION REDUCTIONS

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

As explained in section 1.3 the reference level was updated after some non-material errors were corrected.

See below the adjusted reference level.

Table 4 : ER Program Reference level for the Monitoring/Reporting Period

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 enhanced Removals from afforestation/ reforestation (A/R) (tCO_{2-e}/yr)	If applicable, average annual historical enhanced Removals from other activities besides A/R (tCO_{2-e}/yr)	Adjustment, if applicable (tCO_{2-e}/yr)	Reference Level (tCO_{2-e}/yr)
2023	10,898,269	416,067	0	-52,512	0	11,261,825
2024	10,927,637	416,067	0	-65,640	0	11,278,065
Total	**21,825,906**	**832,134**	**0**	**-118,152**	**0**	**22,539,890**

*Link : https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true

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

Process summary

Activity	Steps	Explanation
Sampling design (LOFM)	Establishment of stratum	Map of land use and change used for the stratification (SOP0) Calculation of stratum weight W_h $W_h = \frac{Area\,of\,stratum}{Total\,area}$
	Identification of number of samples	Use the formula from Cochran, 1977 $n = \left(\sum_{h=1}^{H} \frac{W_h S_h}{SE}\right)^2 = \frac{t^2}{E^2} \times \left(\sum_{h=1}^{H} W_h S_h\right)^2$ Where - n is the number of samples - W_h the weight of stratum - S_h the standard error
Activity data collection (LOFM)	Setting up collect earth forms and templates	SOP1 response design
	Definition of UOT (land use and cover classes changes)	The UOT or "Utilisations et Occupations des Terres" established on 2018, or in English land use and land cover is the system of classification used for all images interpretations. Definitions seen in this link : (https://drive.google.com/file/d/1KACI6QGC30F2y2_zJFRV44hk3MPKk_IP/view?usp=sharing) Forest and non forest classes are defined according to this system of classification For the activity data collection, we defined land use and land cover classes defined in the link below. The document provided in this link explains also the minimal area of a forest which is 0.5 hectare. Each class is corresponding to a definition. The UOT (land use and cover classes changes) here gives the conversion from a class to another, e.g.: forest to non forest wich means deforestation; non forest to forest which signifies gain.
	Collecting AD in Collect earth	SOP1 data collection/response design
Data analysis (LOFM)	Quantity of Forest becoming non-Forest (deforestation)	SOP2 data analysis Step 1 : frequency of deforestation Step 2 : evaluation of area of deforestation Step 3 : evaluation of uncertainties
	Quantity of degradatio	Step 1 : frequency of the estimator Step 2 : area of the estimator

	n: Primary Forest becoming secondary forest	Step 3 : uncertainties
	Estimation of Emission reduction	Step 1 : evaluation of the frequency of gain Step 2 : evaluation of quantity of gain Step 4 |: uncertainties
	Estimation of emission due to fire	Step 1 : evaluation of frequency of fire Step 2 : evaluation of area affected by fire Step 3 : uncertainties
Identification of Emission reduction	Emission factor determination	Step 1 : 459 plots in the humid forest has been surveyed to evaluate the biomass expansion factor and determine the biomass per hectare of forest in the project area Step 2 : Biomass has been converted to Carbon stock
	Emission	Emission for the crediting period is the total of emissions (deforestation, degradation, fire) minus the gain
	Emission reduction or removals (ER)	The Emission Reduction is the difference between the baseline emission compared to the Emission from crediting period
Uncertainties and sensitivity analysis	Monte Carlo simulation	Monte Carlo simulation of all parameters using 10.000 simulation (provided in the“MADA_Uncertainty_Analysis_20240618_V00_for_ER_Report_monitoring_period_2023_2024_v6.2_040626” and https://docs.google.com/spreadsheets/d/10VDZBJ9zHS1srvJkPp8RnC4wJFRJO4hk/edit?usp=sharing&ouid=114519974924085988913&rtpof=true&sd=true

Calculation :
Emission and removals are computed by first calculating areas of loss and gains, applying the Emission factor to the areas to obtain respectively biomass and carbon stock, and deduct the Emission and Removals.
For the loss/emission, we are calculating:

- Deforestation which is defined as the transition from forest to non-forest land use. In this category, there is Primary Forest to non-forest land, secondary forest to non-forest land, and plantation to non-forest land.
- Degradation is the defined as a transition of forest land use into a lower/more degraded land use without leaving the forest definition threshold.

For the gain, we are calculating:

- Gain of forest which is the transition from non-forest land to forest land (non-forest to secondary forest)
- Gain in plantation which is the transition from non-forest land to forest land (non-forest to plantation)

The emission due to fire is calculated by looking at presence of fire as reason of degradation or deforestation (this is identified by looking at the cause of deforestation or degradation and noting if it is due to fire)
The formula to calculate each parameter are the same and we provide here the example of deforestation. Also, all the calculation are made automatic by using R scripts so only the principles are presented here by using the deforestation as an example.

Evaluation of amount of deforestation[***]

The area of deforestation has been calculated by multiplying the total area of the ER Program (sampling frame) A by the stratified estimator of the proportion of the variable i which is deforestation ($\hat{\ }_{DEF}$). One could use other statistical estimators, but the common practice now are stratified estimators.
This value is the proportion of the region of interest classified as deforestation.

$$\hat{A}_{DEF} = A \times \hat{p}_{DEF}$$

To calculate the stratified estimator ($\hat{\ }_{DEF}$), we multiply the weight of each stratum h (W_h) by the proportion of each stratum h ($\overline{p_{h,i}}$)

$$\hat{p}_{DEF} = \sum_{h}^{H} W_h \bar{p}_{h,DEF}$$

The weight is calculated based on the map, the proportion is calculated based on the samples.

Estimate of the confidence interval of the area of deforestation

The absolute error at 90% confidence is equivalent to half the confidence interval (Half Width of the Confidence Interval). We calculate the absolute error with the following equation:

$$Error_{90\%} = t_{student} \cdot \sqrt{\hat{Va}(p_{DEF})}$$

Where, t $t_{student}$ is the t- student at 90% confidence level (aprox . 1.67) and $\sqrt{\hat{Var}(p_{DEF})}$is the standard error or typical deviation of the sample mean. $\hat{Var}(p_{DEF})$ is the variance of the mean, which in this case is the stratified estimator presented above.

The variance is calculated with the following equation, where Wi is the weight of each stratum, ni is the number of samples in each stratum, and $\hat{\sigma}_i^2$is the sampling variance.

$$\hat{Va}(p_{DEF}) = \sum_{h=1}^{H} W_h^2 \times \mathrm{Var}(\bar{p}_{h,DEF})$$

This variance is calculated with the following equation:

$$\hat{\sigma}^2 = \mathrm{Var}(\bar{p}_{h,DEF}) = \frac{p_{h,DEF}(1 - p_{h,DEF})}{n_h - 1}$$

Sample calculation of Emission Reduction

In this sample, step by step calculation is shown in processing of the activity data to the generation of the Emissions and Removals. The steps here are already provided in SOP4 Data analysis.

Inputs :

- Activity data table (results from collect earth[†††]) as “data_with_stratum_preaa_2122”‡‡‡
- Area and weight of each stratum used in the “deforestation_2023-2024”[§§§]
- Area of ERPAA (calculated from the table above)
- R script used to process that data “calcul_defor_gain_for_export_2023_2024.R” (link : https://drive.google.com/file/d/10Q1LKZPnS5P_85qql9AzXRfGeQ83jqOF/view?usp=sharing) and “suivi_2023_2024.R” (link : https://drive.google.com/file/d/1dFCw_wIjGiAyBCkT-fV6WC1Qc1x-Z2yR/view?usp=sharing

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*** https://docs.google.com/spreadsheets/d/1p4KTCCT-e8R2VhX8uuVEKLj1mCPJ-oZW/edit?usp=sharing&ouid=114519974924085988913&rtpof=true&sd=true

https://drive.google.com/file/d/18mDgiuv3LVvrdMrrzeCbHC_67Nw_vQm0/view?usp=drive_link(link to .csv and .zip files of the activity data during the monitoring 2023-2024)

‡‡‡ https://drive.google.com/file/d/17OFK8K27qyy6T53uh118c2W1yOm8Ftm0/view?usp=sharing (link to “data_with_stratum_preaa2324” file)

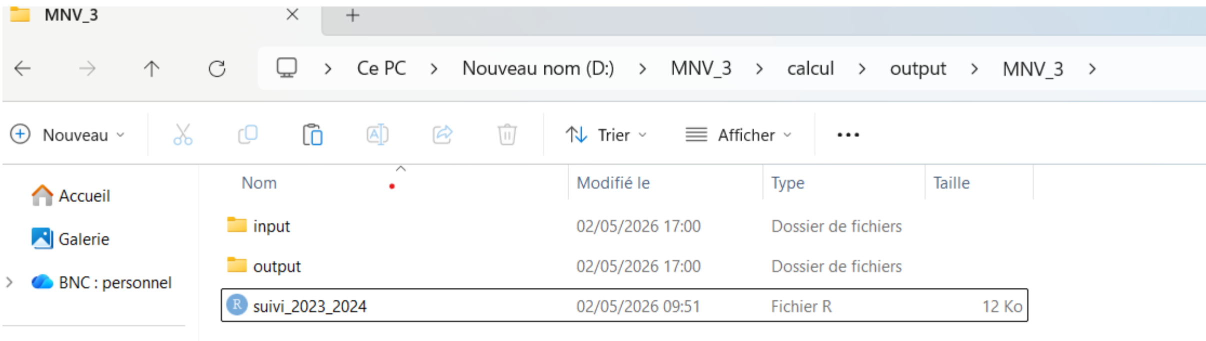
§§§ https://drive.google.com/drive/folders/1O2pUXfjUJ1s5_Cy83DrlfrXOIBqn0US7?usp=sharing

Excel spreadsheet MADA_CalculRE_v00_20250807_update_for_ER_Report_2023_2024_040626_v8.xlsx, link :

https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true

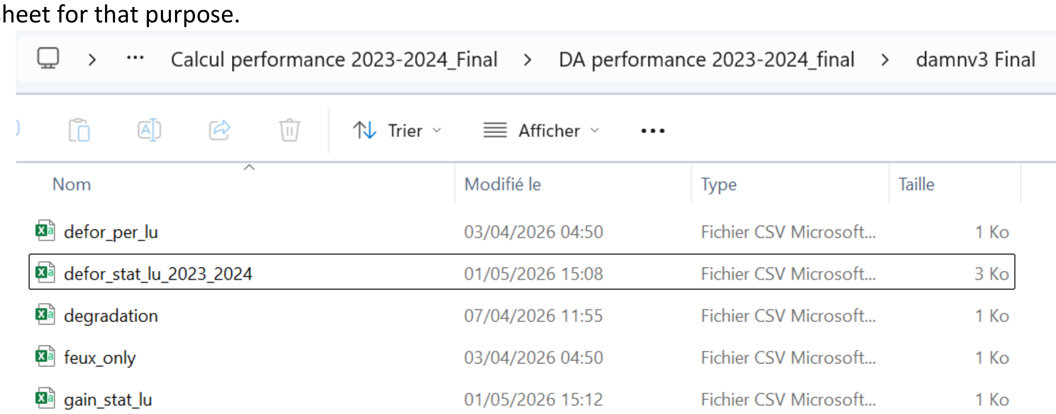
Steps

The script is designed to read input data from a folder input, and write results in folder output. The folder structure is then arranged so that the R script can find the input and output folder, and should then be arranged as in the picture below:



Now, open the script in R-Studio and change the working directory according to where the file is in the computer. Normally, this is the only change to be made on the script and it, but if the activity data have a different name, also change the change the filename.

After the script runs, there will be a few .csv table in the output folder, each of the file corresponds to activity and parameters used to compute the Emissions and removals and values from these files are input into the excel spreadsheet for that purpose.



Defor_stat_lu.csv is the file with the information on deforestation activity. In that file, we are interested in any rows with lu_level2 with the value “FG”, these corresponds to change from Forest to Grassland, or any other non-forest land use. In this example, deforestation occurred in two (02) land use types : FHI (Humid intact forest) and FHD (Degraded Humid Forest). Statistics from each are going to be created manually.

	lu_level2	lu_level3	fq_abs	fq_rel	variance	std_error	uncertainty	area	CI	stratum	wh
1	FF		293	0,976666667	2,49E-06	0,001577943	0,002658056	1269252,296	3373,743395	11	0,181046561
2	FF	FHI	2	0,006666667	7,24E-07	0,000850612	0,209914295	8663,8382	1818,663485	11	0,181046561
3	GG		5	0,016666667	1,79E-06	0,001338149	0,132091504	21659,5955	2861,048549	11	0,181046561
4	FF		13	0,086666667	9,50E-09	9,75E-05	0,001850046	2639,269533	4,882770236	12	0,004242485
5	FF	FHI	2	0,013333333	1,58E-09	3,97E-05	0,004902412	406,0414667	1,990582512	12	0,004242485
6	FG	FHD	78	0,52	2,99E-08	0,00017306	0,000547536	15835,6172	8,670574584	12	0,004242485
7	FG	FHI	5	0,033333333	3,87E-09	6,22E-05	0,003068972	1015,103667	3,115324798	12	0,004242485
8	GG		50	0,333333333	2,67E-08	0,000163293	0,000805952	10151,03667	8,181243729	12	0,004242485
9	GG	SZararb	1	0,006666667	7,95E-10	2,82E-05	0,00695644	203,0207333	1,412301639	12	0,004242485
10	WW		1	0,006666667	7,95E-10	2,82E-05	0,00695644	203,0207333	1,412301639	12	0,004242485
11	FF		124	0,046251399	8,08E-06	0,002843001	0,101128005	232692,4447	23531,72275	22	0,700883925
12	FG	FHD	5	0,001864976	3,41E-07	0,000584022	0,515198953	9382,759866	4833,988056	22	0,700883925
13	FG	FHI	1	0,000372995	6,83E-08	0,000261378	1,15288056	1876,551973	2163,44029	22	0,700883925
14	GG		2523	0,941066766	1,02E-05	0,003187778	0,005572972	4734540,628	26385,46091	22	0,700883925
15	GG	SSar	2	0,00074599	1,37E-07	0,000369575	0,815057556	3753,103946	3058,995731	22	0,700883925
16	OG	ZNA	2	0,00074599	1,37E-07	0,000369575	0,815057556	3753,103946	3058,995731	22	0,700883925
17	OG	ZNZs	1	0,000372995	6,83E-08	0,000261378	1,15288056	1876,551973	2163,44029	22	0,700883925
18	WW		23	0,008578888	1,56E-06	0,001248367	0,239403497	43160,69538	10332,8214	22	0,700883925
19	FF		273	0,91	3,26E-07	0,000570628	0,001031647	225592,4489	232,7317158	55	0,034535986
20	FF	FHI	6	0,02	7,79E-08	0,000279151	0,022962993	4958,0758	113,85226	55	0,034535986
21	FG	FHD	5	0,016666667	6,52E-08	0,000255262	0,025197442	4131,729833	104,1090242	55	0,034535986
22	GG		16	0,053333333	2,01E-07	0,000448032	0,013820687	13221,53547	182,7307038	55	0,034535986
23	FF		662	0,700529101	1,40E-06	0,001181405	0,002774544	398714,1236	1106,250023	56	0,079291042
24	FF	FHI	4	0,004232804	2,80E-08	0,000167456	0,065086702	2409,148783	156,8035488	56	0,079291042
25	FG	FHD	18	0,019047619	1,24E-07	0,000352576	0,030453069	10841,16952	330,1468818	56	0,079291042
26	GG		259	0,274074074	1,32E-06	0,001150505	0,006906208	155992,3837	1077,315777	56	0,079291042
27	WW		2	0,002116402	1,41E-08	0,000118535	0,092144262	1204,574392	110,9946189	56	0,079291042

We know that for estimates from stratified random sampling is as follow :

$$Pi\ (Estimate) = \sum_{i}^{n}((\text{Relative frequency of stratum})\text{x}\ (\text{Weight of the stratum}))$$

$$Variance = \sum Variance\ per\ stratum$$

$$Standard\ error = \sqrt{Variance}$$

Gain_stat_lu.csv contains the gain (regeneration, reforestation), with all the statistics like the above, and calculation of the estimate is the same.

<u>USE OF PARAMETERS (ACTIVITY DATA AND EMISSION FACTORS) FOR THE CALCULATION OF EMISSION MONITORING</u> :

-<u>Calculation of emissions for the monitoring period (cf MADA Calcul RE file, Suivi sheet) (link :</u>

https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true

*<u>Identification of monitoring periods</u>
First, identify the years of emissions tracking. Here, it is the years 2023-2024

*<u>Definition of REDD+ activities considered (deforestation, degradation, enhancement, etc)</u>
The REDD+ activities considered need to be well defined : Here emissions from deforestation and degradation and absorption for enhancement are considered for the calculation of monitored emission.

*Preparation of the AD (data collection, development of the stratification map, confusion matrix, production of results)

We start with the delimitation of the considered areas. We then proceed to the downloading of images (date 1 and date 2) for the stratification map. We work on the classification of images with ROI. Then, we proceed to the sampling of the points to collect. Define the sample sizes according to the definition of forests and finally the collection of data itself using the software collect earth and using different images (Google earth, landsat, sentinel, etc).
At the end of the collection, we obtain information of the csv points identified by sample. The csv file can be changed to excel.

The work carried out at LOFM follows well-defined standard procedures or Standard Operating Procedures (SOPs) :

- The SOP on stratification map creation:
- SOP0
-
- The SOP on sampling:
- SOP1

- The SOP on data interpretation (response system):
  SOP2

- The SOP on data collection:
  SOP3

- The SOP on data Analysis:
  SOP4

Link to FCPF forms including the data reported for the third reporting period : https://drive.google.com/file/d/1JqTAIKmA0Xy6Wwbn52nFJiaw0f8i5tbk/view?usp=sharing

This consolidated csv file of all zones will be used in the script software to output statistics by REDD+ activity and by stratum or land use type (area, absolute frequency, relative frequency, variance, standard error, uncertainty, confidence interval, etc…) (see matrix from example, statistical results from script processing, deforestation activity (FG, Forest to Grassland), below)

	lu_level2	lu_level3	fq_abs	fq_rel	variance	std_error	uncertainty	area	CI	stratum	wh
1	FF		293	0,976666667	2,49E-06	0,001577943	0,002658056	1269252,296	3373,743395	11	0,181046561
2	FF	FHI	2	0,006666667	7,24E-07	0,000850612	0,209914295	8663,8382	1818,663485	11	0,181046561
3	GG		5	0,016666667	1,79E-06	0,001338149	0,132091504	21659,5955	2861,048549	11	0,181046561
4	FF		13	0,086666667	9,50E-09	9,75E-05	0,001850046	2639,269533	4,882770236	12	0,004242485
5	FF	FHI	2	0,013333333	1,58E-09	3,97E-05	0,004902412	406,0414667	1,990582512	12	0,004242485
6	FG	FHD	78	0,52	2,99E-08	0,00017306	0,000547536	15835,6172	8,670574584	12	0,004242485
7	FG	FHI	5	0,033333333	3,87E-09	6,22E-05	0,003068972	1015,103667	3,115324798	12	0,004242485
8	GG		50	0,333333333	2,67E-08	0,000163293	0,000805952	10151,03667	8,181243729	12	0,004242485
9	GG	SZararb	1	0,006666667	7,95E-10	2,82E-05	0,00695644	203,0207333	1,412301639	12	0,004242485
10	WW		1	0,006666667	7,95E-10	2,82E-05	0,00695644	203,0207333	1,412301639	12	0,004242485
11	FF		124	0,046251399	8,08E-06	0,002843001	0,101128005	232692,4447	23531,72275	22	0,700883925
12	FG	FHD	5	0,001864976	3,41E-07	0,000584022	0,515198953	9382,759866	4833,988056	22	0,700883925
13	FG	FHI	1	0,000372995	6,83E-08	0,000261378	1,15288056	1876,551973	2163,44029	22	0,700883925
14	GG		2523	0,941066766	1,02E-05	0,003187778	0,005572972	4734540,628	26385,46091	22	0,700883925
15	GG	SSar	2	0,00074599	1,37E-07	0,000369575	0,815057556	3753,103946	3058,995731	22	0,700883925
16	OG	ZNA	2	0,00074599	1,37E-07	0,000369575	0,815057556	3753,103946	3058,995731	22	0,700883925
17	OG	ZNZs	1	0,000372995	6,83E-08	0,000261378	1,15288056	1876,551973	2163,44029	22	0,700883925
18	WW		23	0,008578888	1,56E-06	0,001248367	0,239403497	43160,69538	10332,8214	22	0,700883925
19	FF		273	0,91	3,26E-07	0,000570628	0,001031647	225592,4489	232,7317158	55	0,034535986
20	FF	FHI	6	0,02	7,79E-08	0,000279151	0,022962993	4958,0758	113,85226	55	0,034535986
21	FG	FHD	5	0,016666667	6,52E-08	0,000255262	0,025197442	4131,729833	104,1090242	55	0,034535986
22	GG		16	0,053333333	2,01E-07	0,000448032	0,013820687	13221,53547	182,7307038	55	0,034535986
23	FF		662	0,700529101	1,40E-06	0,001181405	0,002774544	398714,1236	1106,250023	56	0,079291042
24	FF	FHI	4	0,004232804	2,80E-08	0,000167456	0,065086702	2409,148783	156,8035488	56	0,079291042
25	FG	FHD	18	0,019047619	1,24E-07	0,000352576	0,030453069	10841,16952	330,1468818	56	0,079291042
26	GG		259	0,274074074	1,32E-06	0,001150505	0,006906208	155992,3837	1077,315777	56	0,079291042
27	WW		2	0,002116402	1,41E-08	0,000118535	0,092144262	1204,574392	110,9946189	56	0,079291042

Result after manual processing of this result using the formula, For example, FG (Forest to Grassland) deforestation is estimated using the equation below :
*stratified estimate = fq_rel*wh
Fq_rel = relative frequency
Wh = weight of stratum
*Variance = Variance described in the table above
*Standard error = Square root of Variance

The results of the calculation are in the table below and the data sources are in the table above.

As stated in the above paragraph of the same table containing FG (Forest to Grassland), the results presented in the following table were obtained manually. And these results are used in the MADA file Calculation RE, sheet DA.

area total	6913969	
t	1,6456	
	Deforestation FG	
lu category	**FHI**	**FHD**
Stratified estimate	0,00040	0,005599
Variance	0,00	0,00
Standard error	0,00027	0,000749
Margin of error (90% CI)	0,000442	0,001232
Relative Margin of error (90% CI)	110%	22%
Area (ha)	2785	38712

The same applies to the calculation of gain data, as shown in the following table:

	Gain	GF	
lu category	**PLMS**	**AF**	**FSS**
Stratified estimate	0,000028	0,00060	0,00026
Variance	0,000	0,000	0,000
Standard error	0,000028	0,00031	0,00026
Margin of error (90% CI)	0,000046	0,00051084	0,00043008
Relative Margin of error (90% CI)	164%	86%	164%
Area (ha)	195,549409	4127,98357	1807,49264

* Update of data by REDD+ activities on stratified estimates or estimates, standard errors through statistical results of the ADs (in the file MADA Calcul RE, DA sheet, entitled Suivi) (to update)
Once the matrices from the scripts or statistical results are output, they can be used in the DA sheet by filling the estimate and standard error lines with freq_rel and std_error

*Update of biomass data according to the latest inventories (Excel table,sheet)
The values of biomass, Stdev, Sample number, SE, Relative error, etc have been updated according to the results of the last forest inventory (here, it is the 2020 inventory)

Note that the formula of Veilledent et al (2012) was used for the calculation of aboveground biomass. Indeed, the development of this formula involved data from the forests of eastern Madagascar. Also, the local values obtained from local measurements are the most recommended and approximate the realities. The formula is :

$$AGB = E(-1.103 + 1.994 * Ln(DBH) + 0.317 * Ln\ (H) + 1.303 * Ln\ (\rho)$$

With :

AGB : Above ground biomass, expressed in tons of dry matter (tdm)

ρ : infra density of wood (t/m^3)

DBH : Diameter at Breast Height (DBH) (cm)

H : Total height of the tree (m)

*Calculation of the monitoring emissions itself (Excel table, Suivi sheet) (cf link :

https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true

The calculations of emissions or removals by REDD+ activities are done automatically according to the formulas, and the value of the monitoring emission appears automatically at the bottom (see table whose title is highlighted in green) by following the formula :

Monitoring Emission= Deforestation Emission + Degradation Emission - Absorption

Thus, the average emissions during the monitoring period are obtained, and the value of the monitored emission appears in the column « Net emissions and removals (tCO2-e/yr) » and line 124, here it is the value 18,334,180 tCO2/year.

It should be noted that the calculation of emissions per REDD+ activity follows the formula : Emission (tCO2/year) = Activity Data (AD) x Emission Factors (EF)

AD: Land use change area: Example: deforestation area, obtained through data collection with the collect earth software, expressed in ha/year

EF: It is the amount of CO2 emitted when clearing 1 ha of forest, expressed in tCO2/ha and follows the following formula:

$\boldsymbol{EFj}$ = (Biomass Before, - Biomass After,) $\boldsymbol{x\ CF\ X}$ 44/12 With

$\boldsymbol{E}$: Emission factor for transition j in tons CO2 ha-1.

Biomass Before, : Biomass stock before conversion from forest to non-forest stage, for transition j, in tons of dry matter ha-1

Biomass After, : Biomass stock after conversion from forest to non-forest stage, for transition j, in tons of dry matter ha-1. In the case of dead biomass, the in accordance with the IPCC recommendations for Level 1, the value was considered to be zero.

: Fraction of carbon in dry biomass.

44/12 : Carbon expansion factor at CO2.

-Calculation of the Emission Reduction (cf Réduction d'émissions sheet, link :

https://docs.google.com/spreadsheets/d/1yOJLOeUY9vK0LFg8zx8ocrvsdb85HkV8/edit?usp=sharing&ouid=111291652759547159075&rtpof=true&sd=true

*Update the different parameters of the table to have the number of FCPF emission reductions These parameters are designated by the letters A, B, C, D, E, F, G, H, I, J, K, L,M

The parameter value I comes from the Total reversal risk set-aside percentage presented in Table 7, and the parameter value G comes from the uncertainty discount (cf REL sheet, line 17, AH cell of the Monte Carlo file) (Link : https://docs.google.com/spreadsheets/d/10VDZBJ9zHS1srvJkPp8RnC4wJFRJO4hk/edit?usp=sharing&ouid=114519974924085988913&rtpof=true&sd=true)

Table 5 : Estimation of emissions by sources and removals by sinks

Total emissions for the monitoring period are calculated as the sum of emissions from deforestation, emissions from forest degradation minus removals.

Emission for monitoring period = = 17,871,163+ 562,424 – 99,408= 18,334,179 tCO2e/year

Year of Monitoring/ Reporting Period t	Emissions from deforestation (tCO_{2-e}/yr)	If applicable, Emissions from forest degradation (tCO_{2-e}/yr)	If applicable, enhanced Removals from afforestation/ reforestation (A/R) (tCO_{2-e}/yr)	If applicable, enhanced Removals from other activities besides A/R (tCO_{2-e}/yr)	Net Emissions and Removals (tCO_{2-e}/yr)
2023	8,923,562	281,212	0	-49,704	9,155,070
2024	8,947,603	281,212	0	--49,704	9,179,111
Total	**17,871,164**	**562,425**	**0**	**--99,408**	**18,334,180**

4.3 Calculation of emission reductions

The Excel file containing the tables below can be found at the following link (in the “Section 4.3” sheet) : https://drive.google.com/file/d/1B0nxGtDBEz3Spu8DWBcVI8sSSWDsD0kr/view?usp=sharing

***Total Emissions, Removals and Emission Reductions**:*

T.1	**Deforestation**	**If applicable, forest degradation**	**If applicable, enhanced Removals from afforestation/ reforestation (A/R)**	**If applicable, enhanced Removals from other activities besides A/R***	**Adjustment, if applicable**	**Total (tCO_{2-e})**
Emissions or Removals in the Reference Level (tCO_{2-e})	21,825,906	832,134	0	-118,152	0	22,539,890

Emissions or Removals under the ER Program during the Reporting Period (tCO_{2-e})	17,871,164	562,425	0	-99,408	0	18,334,180
Emission Reductions during the Reporting Period (tCO_{2-e})	3,954,742	269,709	0	-18,744	0	4,205,710

Annual Emissions, Removals and Emission Reductions:

T.2	**Deforestation**		**If applicable, forest degradation**		**If applicable, enhanced Removals from afforestation/ reforestation (A/R)**		**If applicable, enhanced Removals from other activities besides A/R***		**Adjustment, if applicable**		**Total (tCO_{2-e})**	
Year	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**
Emissions or Removals in the Reference Level (tCO_{2-e})	10,898 ,269	10,927 ,637	416,067	416 ,067	0	0	-52,512	-65,640	0	0	11,261 ,825	11,278 ,065
Emissions or Removals under the ER Program during the Reporting Period (tCO_{2-e})	8,923 ,562	8,947 ,603	281,212	281 ,212	0	0	-49,704	--49,704	0	0	9,155,070	9,179,111
Emission Reductions during the Reporting Period (tCO_{2-e})	1,974 ,707	1,980 ,034	134,855	134 ,855	0	0	-2,808	-15,936	0	0	2,106,755	2,098,955

* Please list below which of the ER Program Measures other than A/R that are being considered to generate enhanced Removals:

Total Emissions, Removals and Emission Reductions:

T.3	Deforestation	If applicable, forest degradation	If applicable, enhanced Removals from afforestation/ reforestation (A/R)	If applicable, enhanced Removals from other activities besides A/R	Adjustment, if applicable	Total (tCO_{2-e})
Emissions or Removals in the Reference Level (tCO_{2-e})	21,825,906	832,134	0	-118,152	0	22,539,890
Emissions or Removals under the ER Program during the Monitoring Period (tCO_{2-e})	17,871,164	562,425	0	-99,408	0	18,334,180
Emission Reductions during the Monitoring Period (tCO_{2-e})	3,954,742	269,709	0	-18,744	0	4,205,710
Length of the Reporting period / Length of the Monitoring Period (# days/# days)	731					
Emission Reductions during the Reporting Period (tCO_{2-e})	3,954,742	269,7098	0	-18,744	0	4,205,710

Annual Emissions, Removals and Emission Reductions:

T.4	Deforestation		If applicable, forest degradation		If applicable, enhanced Removals from afforestation/ reforestation (A/R)		If applicable, enhanced Removals from other activities besides A/R*		Adjustment, if applicable		Total (tCO_{2-e})	
Year	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**
Emissions or Removals in the Reference Level (tCO_{2-e})	10,898 ,269	10,927 ,637	416,067	416 ,067	0	0	-52,512	-65,640	0	0	11,261 ,825	11,278 ,065
Emissions or Removals under the ER Program during the Reporting Period (tCO_{2-e})	8,923 ,562	8,947 ,603	281,212	281 ,212	0	0	-49,704	--49,704	0	0	9,155,070	9,179,111
Emission Reductions during the Monitoring Period (tCO_{2-e})	1,974 ,707	1,980 ,034	134,855	134 ,855	0	0	-2,808	-15,936	0	0	2,106,755	2,098,955
Length of the Reporting period / Length of the Monitoring Period (# days/# days)	731											
Emission Reductions during the Reporting Period (tCO_{2-e})	1,974 ,707	1,980 ,034	134,855	134 ,855	0	0	-2,808	-15,936	0	0	2,106,755	2,098,955

Proportion of Emission Reductions per REDD+ activity:

T.5	Emission Reductions during the Reporting Period (tCO_{2-e})	
Year	2023	2024
Total	2,106,755	2,098,955
Emission Reductions from enhanced Removals from afforestation/reforestation as a percentage of the total FCPF ERs (%)	0,00000000%	0,00000000%
If applicable, enhanced Removals from other activities besides A/R (%)	- -0,13323802%	-0,75918731%
If applicable, forest degradation (%)	6,40107350%	6,42486380%
Deforestation (%)	93,73216452%	94,33432351%
Adjustment, if applicable (%)	0,00000000%	0,00000000%

T.6 Year	2023	2024
Emission Reductions from enhanced Removals from afforestation/reforestation as a percentage of the total FCPF ERs (%)	0,00000000%	0,00000000%

5. UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

There is no pro-rata approach for this period. The monitoring period covers 731 days of 2023 and 2024. There is no impact for the uncertainty.

5.1 Identification, assessment and addressing sources of uncertainty

Table 6 : Sources of uncertainty

Sources of uncertainty	**Systematic**	**Random**	**Analysis of contribution to overall uncertainty**	**Contribution to overall uncertainty**	**Addressed through QA/QC?**	**Residual uncertainty estimated?**
Activity Data						
Measurement	✓	✓	This source of uncertainty applies to cases where activity data are based on sampling. This source is related to the visual interpretation of operators and/or field positioning and can be the source of both systematic and random error. This source of Error is generally high, as evidenced by recent studies. Methods for quantifying this source of Error are in the research phase and have not been applied in operational contexts. Therefore, countries will address it through robust quality control procedures that address both systematic and random errors. Robust quality control procedures include : • Written standard operating procedures including detailed labeling protocols; Indeed, there are 5 standard operating procedures that have been written, including a specific one that defines labeling, namely SOP2. SOP2 is for the response design that explains how to assign labels (eg land cover/land use class) to a sample unit. The response plan allows for the best available classification of change for each sampled spatial unit and contains all the information necessary to replicate the process of assigning a label to the sampled unit. The response design defines an objective procedure that interpreters can follow that reduces interpreter bias. • Use of adequate imaging source and multiple imaging sources for labeling;	*High (bias/random)*	*YES*	*NO*

Sources of uncertainty	**Systematic**	**Random**	**Analysis of contribution to overall uncertainty**	**Contribution to overall uncertainty**	**Addressed through QA/QC?**	**Residual uncertainty estimated?**
			Data collection follows a well-defined procedure, with multiple image sources available through the Collect Earth tool. In this sense, the SOP3 is established and followed by each interpreter in order to have the most reliable data possible thanks to the verification by various sources of satellite images covering the study period. SOP3 details how to set up and run data collection for sample-based visual interpretation primarily using remote sensing data to collect sample information. Google Earth, Google Earth Engine and Bing map were both used. • Procedures for training interpreters to ensure proper implementation of SOPs; When collecting data to establish the measure, interpreters were trained in labelling and the actual data collection. Calibration in relation to the classification system used (Land Use and Occupation classification system, forest definitions) was also worked on beforehand. • Reinterpretation of a number of sample units to ensure that SOPs are properly implemented and to identify areas for improvement. During the measurement, a number of samples are reinterpreted at each end of collection session. For quality assurance and quality control: in general, once you fill in the information on a plot, you have to check the information included. Especially if the assigned change of cover and the classes of the two dates studied are logical. Interpreters should have the same line of reasoning and collected data should correspond. Subsequently, an operator other than the one who performed the data collection retests a random sample of 20 percent of the total number of samples during Quality Assurance. For quality control, 5 percent of the total sample plus all change classes and those with low confidence are reanalyzed by the group. /			
Representativeness	✓	x	The sampling is spatially balanced (stratification) and random so the sample is representative of the whole population. Hence, it is considered that this source is negligible.	*Low (bias)*	*YES*	*NO*

Sources of uncertainty	**Systematic**	**Random**	**Analysis of contribution to overall uncertainty**	**Contribution to overall uncertainty**	**Addressed through QA/QC?**	**Residual uncertainty estimated?**
Sampling	x	✓	Sampling uncertainty is the statistical variation in the area estimate for forest transitions that are reported by the ER Program. This source of Error is random, but estimator selection can be a source of Error. ER programs should use baseline data and unbiased estimators to estimate activity data and uncertainty, as recommended by the GFOI MGDFor more information on how estimates can be produced using unbiased estimates of activity data, please refer to Area Estimation FAQ and GFOI MGD Section 5.1.5 (GFOI 2016), Good Practices for Estimating Areas and Evaluating olofsson et al. Section 5.1.5 (2014). The choice of an appropriate estimator would also be a source of uncertainty that must be addressed through quality control procedures. A stratification map has been established. When drawing up this map, omission errors for the deforestation stratum were reduced as much as possible (strata studied: deforestation, forest, non-forest, buffers in the edges of forests). From this stratification map, the sampling units were generated. Thus, the number of samples necessary to obtain the optimal precision was determined in stages: first a pilot study to determine the variability of the estimator and identify the initial number of samples necessary. At each step, the precision is estimated and the errors evaluated using the uncertainty calculation table () (calcul_uncertainty_v8_20260502), the iteration continues until the optimal uncertainty is obtained. The link is https://docs.google.com/spreadsheets/d/1cU6-WQAn8NSqOi2qxJtdJ176Z86wpH1g/edit?usp=sharing&ouid=114519974924085988913&rtpof=true&sd=true	*High (random / bias)*	*YES*	*YES*
Extrapolation	✓	x	Not applicable since no extrapolation was done, i.e. activity data was estimated directly through the sampling approach without using auxiliary data.	*L (bias)*	*YES*	*NO*
Approach 3	✓	x	Since there is the impossibility of a non-forest land to become forest land in just one year (length of the monitoring period), this specific conversion of land cover (non-forest to forest) is not evaluated and associated errors assumed zero or negligible	*L (bias)*	*YES*	*NO*

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty	Addressed through QA/QC ?	Residual uncertainty estimated?
Emission factor						
DBH measurement	✓	✓	The error during the inventory is minimal because on one hand, the training of the team was well organized and on the other, most of the team already have experience in inventory. The diameters (DBH) are measured at chest height (1.30m) with a circumferential tape. In order to facilitate the identification of the DBH measurement height, the surveyor will obtain a 1.30 meter stick which he will attach to the trunk of the tree to be measured. The measurement error is minimal because there is already a protocol to follow, especially for the use of measuring equipment. Two types of height are recorded : total height and commercial height was : for all trees over 20 cm DBH, take both measurements and for others only the total height The height is measured using a hypsometer or vertex, following the instructions of the instrument. It can be raised with Bitterlich's Relascope To avoid errors, it is necessary to be at a distance at least equal to the height to have the two sights: the top and the foot of the tree. If the operator is located at the top of the slope, the two measurements are added and if the operator is at the bottom of the slope in relation to the tree, subtract the two targets. In the SOP on the inventory manual, there is already a diagram of the plot device to follow for the delimitation and the materialization of the plot. Measurement errors are minimized by : - The establishment of a clear and precise inventory manual (BNCCREDD+. 2020, Terrestrial forest inventory manual. 25 pages. Antananarivo. Madagascar)	H (bias) & L (random)	*YES*	*NO*
H measurement	✓	✓		H (bias) & L (random)	*YES*	*NO*
Plot delineation	✓	✓		H (bias) & L (random)	*YES*	*NO*

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty	Addressed through QA/QC?	Residual uncertainty estimated?
			- The recruitment of experienced staff for the inventory - The training of technicians and preparatory meeting before field missions - The use of adequate and standard equipement with all missions to minimize errors caused by instruments By quality controls carried out on random plots			
Wood density estimation	✓	✓	WSG (Wood Specific Gravity) values used expressed in g/cm3 have been sourced from different publications using a decision tree and strong QA/QC procedures to ensure the most accurate or conservative value. Research in Madagascar by Ramananantoandro et al. (2015) has shown that WSG values from literature overestimate measured WSG by 16% on average. However, effects on biomass estimates were found to be not significant at the 95% confidence level (c.f. section 12 of ERPD) so this has been neglected.	*Low (random)*	*YES*	*NO*
Biomass allometric model	✓	✓	The allometric model error can be divided in the following sources. a. the error due to the uncertainty of the model's coefficients. b. the error linked to the residual model error; c. the selection of the allometric model. According to Picard et al. (2015) [****] the largest uncertainty is due to the selection of the allometric model which may be 77% of the mean biomass estimate. Van Breugel et al. (2011) [††††] estimated that the errors linked to the allometric equation could vary from 5 to35% depending on the model selected. The third error (c) is assumed to be negligible for the woody biomass species as these equations are calibrated with trees measured within the same ecoregion or even the ER program area. The other two errors (a and b) were found to be not significant at the 95% confidence level,	*Low (bias) & Low (random)*	*YES*	*NO*

[****] Picard et al. (2015) Error in the estimation of emission factors for forest degradation in central Africa. J For Res DOI 10.1007/s10310-015-0510-5

[††††] Van Breugel et al. (2011) Estimating carbon stock in secondary forests: Decisions and uncertainties associated with allometric biomass models. Forest Ecology and Management 262 (2011) 1648–1657

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty	Addressed through QA/QC?	Residual uncertainty estimated?
			so this has been neglected but they will be considered in the quantification. The allometric equation of Vieilledent et al (2012) was used to quantify aboveground biomass.			
Sampling	x	✓	Sampling design and implementation is one of the main sources of errors. This will be considered in the quantification of uncertainty. The measures that have been implemented to manage and reduce these sources of uncertainty are : SOP application, training of technician, QA/QC control.	*H (random / bias)*	*YES*	*YES*
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	✓	✓	Uncertainty from other parameters, such as root-to-shoot ratios and CF will be propagated. Selection of parameters was done in accordance with the IPCC Guidelines and guidance ensuring the most accurate or conservative estimate.	*H (bias / random)*	*YES*	*YES*
Representativeness	✓	x	The lack of representativeness usually causes bias, i.e. if the sample is not representative of the population. In the case of MNF this could be a source of uncertainty as the estimate is based on samples from different forest types. However, the MNF biomass stocks estimate is conservative (samples in degraded forest or single layer were not considered) in terms of reducing emissions and ERs, so it is assumed that this source of error is negligible.	*Low (bias)*	*YES*	*NO*
Integration						
Model	✓	x	Although the simple multiplication of AD and EF does not contain any error, there are some assumptions such as assuming that after deforestation there is an instantaneous transfer of AGB and BGB to the atmosphere or that the biomass in non-forest grows immediately after conversion. The former assumption is based on best practices, while the latter is conservative in terms of GHG emissions and emission reductions. Another potential source is that it is assumed that the carbon stocks of deforested forests is equal to the	*Low (bias)*	*YES*	*NO*

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty	Addressed through QA/QC?	Residual uncertainty estimated?
			average of all forests, whether they are primary or not. This last assumption is partially corrected in the RL by separating the stratum of primary forest and the stratum of modified natural forest (with higher deforestation and lower biomass stocks). Another error might be the ages assumed in order to estimate the transition from non-forest to modified natural forest. This error has been taken into consideration.			
Integration	✓	x	This issue has been solved through the forest inventory which was based on a random sample of plots of the national grid interpreted via collect earth. This ensures the comparison of apples with apples as the emission factors are based on the forest classification observed via remote sensing, not in-situ.	*Low (bias)*	*YES*	*NO*

5.2 Uncertainty of the estimate of Emission Reductions

Parameters and assumptions used in the Monte Carlo method

REFERENCE LEVEL				
Parameter included in the model	**Parameter values**	**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Assumptions**
Annual deforestation primary forest (ha/year)	2,724.10/ SE 656.83	656.83	Normal	above zero
Annual deforestation disturbed forest (ha/year)	22,304.46/ SE 1,859.86	1,859.86	Normal	above zero
Annual deforestation secondary forest (ha/year)	159.02 / SE 159.02	159.02	Normal	above zero
Annual deforestation agroforestry (ha/year)	159.02 / SE 159.02	159.02	Normal	above zero
Annual deforestation plantation (ha/year)	0.00/ SE 0.00	0.00	Normal	above zero
Annual forest regrowth secondary forest (ha/year)	802.02	352.61	Normal	above zero

	/SE 352.61			
Annual forest regrowth agroforestry (ha/year)	0.00/SE 0.00	0.00	Normal	above zero
Annual forest regrowth plantation (ha/year)	0.00/SE 0.00	0.00	Normal.	above zero
Annual degradation Primary forest to disturbed forest (ha/year)	11,712.26 / SE 1,355.14	1,355.14	Normal	above zero
Annual degradation Primary forest to agroforestry (ha/year)	0.00 / SE 0.00	0.00	Normal	above zero
Annual degradation Primary forest to plantation (ha/year)	0.00/ SE 0.00	0.00	Normal	above zero
Annual degradation Disturbed forest to agroforestry (ha/year)	0.00/ SE 0.00	0.00	Normal	above zero
Annual degradation Disturbed forest to plantation (ha/year)	0.00/ SE 0.00	0.00	Normal	above zero
AGB primary forest (tdm/ha)	202.63 / SE 8.00	8.00	Normal	above zero
AGB disturbed forest (tdm/ha)	186.00 / SE 12.14	12.14	Normal	above zero
AGB secondary forest (tdm/ha)	91.11 / SE 15.88	15.88	Normal	above zero
AGB agroforestry (tdm/ha)	87.87 / SE 7.64	7.64	Normal	above zero
AGB plantations (tdm/ha)	29.55 / SE 6.25	6.25	Normal	above zero
AGB non-forest (tdm/ha)	11.96 / SE 3.28	3.28	Normal	above zero
RSR >125 tdm/ha (dimensionless)	0.24 / range 0.22-0.33	Sampling error	Uniform	No assumption
RSR <125 tdm/ha (dimensionless)	0.20 / range 0.09-0.25		Uniform	No assumption
RSR Eucalyptus (dimensionless)	3.24/ range 2.74-4.26		Uniform	No assumption
SOCbefore (tC/ha)	110.97 / SE 3.50	3.50	Normal	above zero
SOCafter (tC/ha)	104.65 / SE 4.33	4.33	Normal	above zero
FMG Deforestation (dimensionless)	1.22 / SE 0.07	0.07	Normal	above zero
FI Deforestation (dimensionless)	0.92 / SE 0.14	0.14	Normal	above zero
D Deforestation (dimensionless)	1.00 / SE ##		Normal	above zero
Dead wood content deforestation primary forest (tdm/ha)	12.93 / SE 1.34	1.34	Normal	above zero
Dead wood content deforestation disturbed forest (tdm/ha)	12.13 / SE 0.88	0.88	Normal	above zero

Dead wood content deforestation secondary forest (tdm/ha)	10.61/ SE 5.56	5.56	Normal	above zero
Dead wood content deforestation agroforestry (tdm/ha)	10.88/ SE 5.7	5.70	Normal	above zero
Dead wood content deforestation plantation (tdm/ha)	0.00 / SE 0.00	0.00	Normal	above zero
Dead wood content deforestation non forest (tdm/ha)	0.00/ SE 0.00	0.00	Normal	above zero
Litter content deforestation - forest (tC/ha)	2.10 /range 1.00-3.00		Uniform	No assumption
Litter content deforestation - non forest (tC/ha)	0.00 /range 0.00-0.00		Uniform	No assumption
Combustion factor - Primary tropical forest-Non-CO2 emissions (dimensionless) (slash and burn)	0.50 /SE 0.03	0.03	Normal	above zero
Secondary tropical forest (slash and burn) -Non-CO2 emissions (dimensionless)	0.55 /SE 0.06	0.06	Normal	above zero
Emission factor CH4 Tropical forest-Non-CO2 emissions (g/kg)	6.80 / SE 2.00	2.00	Normal	above zero
Emission factor N2OTropical forest-Non-CO2 emissions (g/kg)	0.20 /SE 0.10	0.10	Normal	above zero
Age secondary forest-Forest gain (year)	20.00 /range 12.00-18.00		Uniform	No assumption
Age agroforestry-Forest gain (year)	20.00 /range 12.00-18.00		Uniform	No assumption
Age plantations-Forest gain (year)	5.00 /range 3.00-7.00	0.00	Uniform	No assumption
Age non forest-Forest gain (year)	10.00/range 3.00-7.00	0.00	Uniform	No assumption
CF (Carbon fraction, Tropical and subtropical ; all)	0.47 /range 0.44-0.49	NA	Uniform	No assumption
Conversion Factor to CO2	3.67	NA	NA	NA
Reference period (year)	10.00	NA	NA	NA
GWP (CH4)	28.00	NA	NA	NA
GWP (N2O)	265.00	NA	NA	NA
MONITORING				
Annual deforestation primary forest (ha/year)	**1,392.62**	**928.79**	Normal	Above zero

Annual deforestation disturbed forest (ha/year)	**19,356.10**	**2,588.12**	Normal	Above zero
Annual deforestation secondary forest (ha/year)	**0.00**	**0.00**	Normal	Above zero
Annual deforestation agroforestry (ha/year)	**0.00**	**0.00**	Normal	Above zero
Annual deforestation plantation (ha/year)	**0.00**	**0.00**	Normal	Above zero
Annual forest regrowth-Forest gain-secondary forest (ha/year)	**903.75**	**903.58**	Normal	Above zero
Annual forest regrowth-Forest gain-agroforestry (ha/year)	**2,063.99**	**1,073.11**	Normal	Above zero
Annual forest regrowth-Forest gain-plantation (ha/year)	**97.77**	**97.45**	Normal	Above zero
Annual degradation-Primary forest to disturbed forest (ha/year)	**7,916.10**	**3,151.52**	Normal	Above zero
Annual degradation-Primary forest to agroforestry (ha/year)	**0.00**	**0.00**	Normal	Above zero
Annual degradation-Primary forest to plantation (ha/year)	**0.00**	**0.00**	Normal	Above zero
Annual degradation-Disturbed forest to agroforestry (ha/year)	**0.00**	**0.00**	Normal	Above zero
Annual degradation-Disturbed forest to plantation (ha/year)	**0.00**	**0.00**	Normal	Above zero

Quantification of the uncertainty of the estimate of Emission Reductions

(link : https://docs.google.com/spreadsheets/d/10VDZBJ9zHS1srvJkPp8RnC4wJFRJO4hk/edit?usp=sharing&ouid=114519974924085988913&rtpof=true&sd=true)

		Reporting Period	Crediting Period
		Total Emission Reductions*	**Total Emission Reductions***
A	**Median**	**5,840,386**	22,544,882
B	**Upper bound 90% CI** (Percentile 0.95)	10,851,700	29,449,540
C	**Lower bound 90% CI** (Percentile 0.05)	889,153	16,021,711

D	**Half Width Confidence Interval at 90% (B – C)/ 2**	4,981,273	6,713,915
E	**Relative margin (D / A)**	85%	**30%**
F	**Uncertainty discount**	**12%**	**4%**

*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

Referring to criterion 7 (link : https://www.forestcarbonpartnership.org/system/files/documents/fcpf_guidelines_on_uncertainty_analysis_2020_0.pdf) and indicators 9.2 and 9.3 of the Methodological Framework and the Guideline on the application of the Methodological Framework Number 4 On Uncertainty Analysis of Emission Reductions, a sensitivity analysis was undertaken to identify the relative contribution of each parameter to the overall uncertainty. Sensitivity analysis was undertaken by systematically disabling a parameter and noting the change in overall uncertainty of the emission reduction. This process was done by turning the parameter off (changing from include parameter = YES to include parameter = NO, noting the parameters and putting the parameter back on before moving to the next parameter, this scenario assumes the parameter is error free permitting the enhancement to the uncertainty provided by that parameter.

Table 7: Sensitivity analysis (lists only the parameters that can be controlled by the project)

Scenario	Uncertainty 90% CI	Difference to ER Uncertainty 90% of all parameters
All parameters	25	0
No reference level Deforestation	25	0
No reference level Degradation	25	0
No reference level Enhancement	24	-1
No Emission factor	24	-1
No Root to shoot ratio	24	-1
No monitoring level deforestation	13	-12
No monitoring level degradation	25	0
No monitoring level Enhancement	25	0

Results indicate that the exclusion of several parameters—including reference level estimates for deforestation and degradation, as well as monitoring of degradation and enhancement—does not result in any change in overall uncertainty. This suggests that these parameters have a negligible influence on the total uncertainty of ER estimates within the current MRV configuration.

A marginal reduction in uncertainty (1 percentage point) is observed when excluding the reference level for enhancement, emission factors, and the root-to-shoot ratio. These parameters therefore contribute to overall uncertainty to a limited extent, and improvements in their estimation would yield only incremental reductions in total uncertainty.

By contrast, the monitoring of deforestation is identified as the primary driver of uncertainty. When this parameter is excluded, the total uncertainty decreases significantly from 25% to 13% (a reduction of 12 percentage points). This indicates that uncertainties associated with activity data for deforestation—such as land-use classification, change detection accuracy, and associated area estimates—dominate the overall uncertainty of ERs.

Looking only at the 3rd year, results of the sensitivity analysis are presented in the tables below (with a link showing the calculation :
https://docs.google.com/spreadsheets/d/19tEB92PgZM8ahF2b7F5DNJnUQdIDJoCp/edit?usp=sharing&ouid=114519974924085988913&rtpof=true&sd=true

ER 3rd (year)	All parameters	
	Value calculated MC tool	**5 738 513**
A	**Median**	**2 946 973**
B	**Upper bound 90% CI** (Percentile 0.95)	5 446 674
C	**Lower bound 90% CI** (Percentile 0.05)	490 860
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 477 907
E	**Relative margin (D / A)**	84%

ER 3rd (year)	No reference level Deforestation	
	Value calculated MC tool	**5 738 513**
A	**Median**	**1 564 519**
B	**Upper bound 90% CI** (Percentile 0.95)	3 872 390
C	**Lower bound 90% CI** (Percentile 0.05)	-942 764
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 407 577
E	**Relative margin (D / A)**	154%

ER 3rd (year)	No reference level Degradation	
	Value calculated MC tool	**5 738 513**
A	**Median**	**2 926 310**
B	**Upper bound 90% CI** (Percentile 0.95)	5 521 603
C	**Lower bound 90% CI** (Percentile 0.05)	459 552
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 531 025
E	**Relative margin (D / A)**	86%

ER 3rd (year)	No reference level Enhancement	
	Value calculated MC tool	**5 738 513**

A	**Median**	**2 919 771**
B	**Upper bound 90% CI** (Percentile 0.95)	5 422 400
C	**Lower bound 90% CI** (Percentile 0.05)	465 915
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 478 243
E	**Relative margin (D / A)**	85%

ER 3rd (year)	No monitoring level Deforestation	
	Value calculated MC tool	**5 738 513**
A	**Median**	**8 360 771**
B	**Upper bound 90% CI** (Percentile 0.95)	10 574 016
C	**Lower bound 90% CI** (Percentile 0.05)	6 304 020
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 134 998
E	**Relative margin (D / A)**	26%

ER 3rd (year)	No monitoring level Degradation	
	Value calculated MC tool	**5 738 513**
A	**Median**	**3 020 788**
B	**Upper bound 90% CI** (Percentile 0.95)	5 526 687
C	**Lower bound 90% CI** (Percentile 0.05)	509 540
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 508 573
E	**Relative margin (D / A)**	83%

ER 3rd (year)	No monitoring level Enhancement	
	Value calculated MC tool	**5 738 513**
A	**Median**	**2 874 797**
B	**Upper bound 90% CI** (Percentile 0.95)	5 381 035
C	**Lower bound 90% CI** (Percentile 0.05)	405 349
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 487 843
E	**Relative margin (D / A)**	87%

ER 3rd (year)	No Root to shoot ratio	
	Value calculated MC tool	**5 738 513**
A	**Median**	**2 855 173**
B	**Upper bound 90% CI** (Percentile 0.95)	5 340 209
C	**Lower bound 90% CI** (Percentile 0.05)	465 889
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 437 160
E	**Relative margin (D / A)**	85%

ER 3rd (year)	No Emission factor	
	Value calculated MC tool	**5 738 513**

A	**Median**	**2 956 696**
B	**Upper bound 90% CI** (Percentile 0.95)	5 416 704
C	**Lower bound 90% CI** (Percentile 0.05)	490 393
D	**Half Width Confidence Interval at 90% (B – C)/ 2**	2 463 156
E	**Relative margin (D / A)**	83%

6. TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

Madagascar has demonstrated its capacity to transfer titles to Emission Reductions (ERs). The title to ERs is State property in accordance with the provisions of Decree No. 2013-785 of October 22, 2013 establishing the modalities for delegated management of State forests by public or private entities. Article 52 of the decree stipulates that “all woody and non-woody forest products, tangible or intangible, including forest carbon, remain the property of the State, the management of which falls exclusively under the responsibility of the Forestry Administration.”

Decree No. 2018-500 of May 30, 2018 adopting the National REDD+ Strategy of Madagascar further specifies that the “property right over carbon” belongs exclusively to the State through the forestry administration. The contractualization of emission reduction payment agreements, as well as the principles governing the sharing of generated revenues, fall under the prerogative of the State.

Madagascar has revised the Decree regulating access to the forest carbon market with the objective of facilitating the implementation of ongoing initiatives and programs, encouraging future initiatives and programs, and ensuring alignment with the new rules under Article 6 of the Paris Agreement. The retroactive effect of the decree provides legal certainty to existing initiatives and programs without affecting acquired rights.

The new Decree No. 2025-626 repeals Decree No. 2021-1113 of October 20, 2021 on the regulation of access to the forest carbon market, without affecting the State’s capacity to transfer certified ERs. This capacity is maintained and reaffirmed under Article 10.

In accordance with Article 10(a) applicable to REDD+ activities, the Malagasy State has the exclusive authority to claim ownership, commercialize, and transfer titles to emission reductions.

In addition, Madagascar has established a Designated National Authority (DNA) under Article 6 of the Paris Agreement, responsible in particular for the review and approval of carbon projects developed on private lands and in non-forest areas. In order to ensure consistency across carbon accounting systems and prevent any risk of double claiming or double counting, coordination and cross-checking mechanisms have been established between the DNA and the BNCCREDD+.

In cases where non-REDD+ carbon projects, particularly ARR projects implemented on non-forest lands, are developed within or in proximity to the Program area, this coordination process aims to ensure the compatibility of activities, methodological boundaries, relevant strata, and accounting periods, in order to guarantee that the claimed emission reductions or removals are not subject to double claiming or double counting under the ERPAA framework.

Within this framework, any approval decision for activities defined under Article 10(b) of the decree, as well as any letter of no-objection related to activities referred to under Article 10(c), is centralized at the BNCCREDD+ level and issued by the National Coordinator.

The BNCCREDD+ is the main entity responsible for implementing the decree related to forest carbon and for coordinating forest carbon initiatives across the national territory. Any approval or authorization issued under carbon mechanisms is subject to an institutional verification process aimed at ensuring the compatibility of activities, methodological boundaries, and relevant accounting periods, in compliance with the commitments related to the ERPA.

6.2 Implementation and operation of Program and Projects Data Management System

Description of the Information System on REDD+ Program and Initiatives

In accordance with the national regulatory framework governing access to the forest carbon market, the BNCCREDD+ has established a national system for managing information related to REDD+ programs and initiatives.

Initially designed as a digital platform dedicated to monitoring REDD+ initiatives, the SIIP is currently not accessible online due to technical and contractual constraints related to web hosting. However, the core functions of the system remain operational through internal databases and Filing system, cartographic tools, and verification procedures managed by the BNCCREDD+.

The system currently in use enables, among others:

- the registration of REDD+ programs and initiatives;
- the archiving of technical documents and approval decisions;
- the monitoring of project geographical boundaries;
- spatial and temporal overlap checks;
- the coordination of verification processes with other relevant national institutions.

The data are centralized and maintained by the BNCCREDD+ through internal databases and GIS tools used by the technical and MRV teams.

In order to prevent risks of double counting, a national verification protocol is applied to any carbon initiative identified within or in proximity to the ERPAA Program boundary. This protocol includes:

- the analysis of project technical information;
- the verification of geographical boundaries;
- the review of crediting periods;
- cross-checking with databases managed by the Designated National Authority (DNA) for projects related to Article 6 mechanisms;
- additional territorial verifications where deemed necessary.

Since 2025, a member of the REDD+ technical team has also been integrated within the Designated National Authority (DNA) structure in order to strengthen coordination between REDD+ and Article 6 mechanisms and to ensure that the REDD+ coordination is informed of all carbon projects under review or processing. This institutional arrangement was introduced as a corrective measure to further reinforce the national system for preventing overlap and double counting.

Information Management and Governance Rules

The BNCCREDD+ is responsible for the administration, management, and updating of information related to REDD+ programs and initiatives. In accordance with Decree No. 2025-626, it is the entity responsible for issuing validation for forest carbon projects implemented within State-owned lands.
Any REDD+ initiative or carbon project seeking registration and approval/accreditation shall submit the required information and supporting documentation to the BNCCREDD+, as specified under the Forest Carbon Decree.
Upon receipt or identification of an initiative, the BNCCREDD+ opens a technical file and records the available information within the databases and information management tools used for this purpose.
The Program Management Division, in collaboration with the other technical divisions, is responsible for:

- collecting and updating information related to initiatives;
- managing technical files;
- conducting preliminary verifications;
- identifying risks of overlap and double counting.

The Methodology Division and the Forest Observation Laboratory are responsible for:

- conducting geospatial verification of overlaps;
- analyzing emission reduction accounting boundaries;
- carrying out technical analyses related to carbon accounting and the prevention of double counting.

The Head of the REDD+ department is responsible for coordinating any additional technical analyses when required.

Where necessary, information may be cross-checked with data held by the Designated National Authority (DNA), the Regional Directorates for Environment and Sustainable Development (DREDD), the competent forestry services, or any other relevant institution.
Each initiative is assigned a unique technical file containing all relevant information and documentation, including technical documents, maps, geospatial analyses, verification results, institutional correspondence, and decisions taken during the review process.

Any substantial modification relating to geographic boundaries, the crediting period, the methodology, the project proponent, or any other characteristic likely to influence verification results shall be communicated to the BNCCREDD+ in order to allow the update of the technical file and, where necessary, the conduct of additional verification procedures.

The results of the verification processes are reviewed and validated by the BNCCREDD+ coordination before being archived. All documents, analyses, and records related to the verification process are retained in order to ensure transparency, traceability, and consistency of the decisions taken.

How the protocol works

The objective of this protocol is to:

- verify the absence of overlap between carbon initiatives;
- prevent risks of double counting of emission reductions or removals;
- ensure consistency between REDD+ initiatives and other carbon mechanisms;
- guarantee traceability of verification procedures;

Verification Protocol Steps

Step 1 – Registration and Preliminary Documentation of the Initiative

Responsible entity: Program Management Division

Any carbon initiative submitted to the BNCCREDD+ for registration, approval, or recognition, or identified through national monitoring mechanisms, undergoes preliminary registration.
The information collected includes, as applicable:

- project name;
- project proponent;
- type of carbon activity;
- location and geographic boundaries;
- crediting period;
- methodology applied;
- available technical documentation (PDD, maps, etc.)

Expected Result: Creation of a technical file enabling the identification and monitoring of the initiative.

Step 2 – Preliminary Documentary and Geographic Verification

Responsible entity: Program Management Division
A preliminary review is conducted using available databases, documentary records, and geospatial information in order to identify any apparent risk of overlap requiring further assessment.
This review focuses on:

- the location and geographic boundaries of the initiative;
- potential geographic overlaps with registered initiatives;
- potential overlap of crediting periods;
- compatibility of the proposed carbon activities with existing initiatives;

- the presence of the initiative within or in proximity to the ERPAA Program area.

Where necessary, additional information may be requested from decentralized services or relevant institutions.

Expected Result: Identification of the existence or absence of preliminary overlap risks requiring further assessment.

Step 3 – Institutional Cross-Checking

Responsible entity: Head of the REDD+ Department, which is the focal point within the Designated National Authority (DNA)

Where an initiative falls under, or may potentially fall under, other carbon mechanisms, institutional cross-checking is undertaken with the relevant authorities, including the Designated National Authority (DNA).

The cross-checking may include:

- projects already approved;
- projects under review;
- geographic boundaries;
- crediting periods;
- applicable carbon mechanisms and methodologies.

Expected Result: Identification of situations requiring further technical assessment.

Step 4 – Detailed Technical Assessment

Responsible entities: Methodology Division and Forest Observation Laboratory (MRV Team)

Where a potential overlap or double-counting risk has been identified, a detailed technical assessment is conducted.

This assessment may include:

- analysis of accounting boundaries;
- comparison of activities and methodologies;
- review of geospatial data;
- analysis of carbon accounting approaches;
- assessment of claimed emission reductions or removals;
- review of stratification, activity data and quantification parameters where relevant;
- any additional technical analysis required to determine the existence of a double-counting risk.

The purpose of this assessment is to determine whether the emission reductions or removals claimed by the initiative overlap with those already accounted for under the ERPAA Program or any other registered initiative.

Expected Result: Determination of whether an actual risk of double counting exists.

Step 5 – Validation and Archiving

Responsible entity: Program Management Division, with validation by the BNCCREDD+ Coordination

The results of the verification process are documented, reviewed, validated and archived within the technical file of the initiative.

Documentation may include:

- technical analyses;
- maps and geospatial assessments;
- technical notes;
- relevant institutional correspondence;
- decisions taken during the review process.

Where no risk of double counting is identified, the initiative may proceed to the subsequent stages of the registration and homologation process concerning institutional, safeguards and benefit sharing mechanism assessment.

Where a risk is identified, corrective measures, restrictions, or additional conditions may be required prior to any validation, approval, or carbon-related authorization.

Expected Result: Full traceability of the verification process and the decisions taken.

Application of the Protocol during the 2023–2024 Reporting Period

As part of the cross-checking exercises conducted between the BNCCREDD+ and the Designated National Authority (DNA), the “Fagnako” project, developed by Canopy and involving Afforestation, Reforestation and Revegetation (ARR) activities, was identified within or in proximity to the ERPAA Program area.

This project had been reviewed prior to the establishment of the current coordination and information-sharing mechanisms between the REDD+ team and the DNA. Its identification during the cross-checking exercises led to the application of the present protocol in order to assess potential risks of overlap and double counting.

A complementary technical analysis was therefore conducted by the Methodology Division and the Forest Observation Laboratory.

At the time of this analysis, although the project had planned a crediting period starting in 2023, no carbon units had been issued or registered under the project.

The analysis focused in particular on the project’s geographic boundaries, the activities implemented, the accounting boundaries, as well as the emission reductions and removals that could potentially be claimed.

The results demonstrated that:

- the project exclusively involves ARR afforestation and reforestation activities;
- the activities implemented are distinct from the REDD+ activities accounted for under the ERPAA Program;
- the ERPAA Program did not account for any carbon benefits originating from the area covered by the ARR initiative;
- although a partial geographic overlap was identified, no overlap of emission reductions or removals accounted for, or likely to be accounted for, during the 2023–2024 reporting period was identified.

The analysis therefore concluded that there is no risk of double claiming or double counting between the Fagnako project and the ERPAA Program.

6.3 Implementation and operation of ER transaction registry

For ERs generated under Atiala Atsinanana Emission Reduction Program, Madagascar agrees to use the World Bank Carbon Asset Tracking System (CATS) registry to manage the Program's certified ER units.

It should also be noted that only the Government through the Ministry of the Environment has the capacity to sign payment agreements and to market Emission Reductions. It is this same entity that carries out the validation of carbon projects (including on voluntary markets), and which also makes the corresponding adjustment related to the NDC to avoid double counting.

The formalities involved in creating an account in the CATS register and appointing authorized person have been completed. A letter naming the person whose authenticated specimen signature, to deliver required documents, and evidence in support thereof on the terms and conditions specified in the ERPAs and be responsible to communicate with the Trustee of the Carbon Fund regarding any changes to Program Entity and its users of CATS is signed. The person is Lovakanto Njaran’ny Fo RAVELOMANANA, Coordinator of the Climate Change and REDD+ National office

The onboarding form for External Entities and Users of The World Bank’s Carbone Assets Tracking System (CATS) is filled and signed.

Information for external entities

- Name of the entity/company: Government of Madagascar
- Website address for the entity/company:
- Ministry of Environment an Sustainable Development: https://www.environnement.mg Ministry of economy and Finance: http://www.mef.gov.mg
- Names and addresses of the Entity's Head Quarter:
- Ministry of Environment and Sustainable Development, Antsahavola Toto RADOLA Road Antananarivo
- Ministry of economy and Finance, 14 Rabehevitra Road Antananarivo
- Names and addresses of branches of the entity: National Office of Climate Change and REDD+: Nanisana Iadiambola, near DREDD Analamanga Antananarivo

Information for CATS users

- Approver full name: Lovakanto Njaran'ny Fo RAVELOMANANA
- Transaction processor: Hasina Rijatahiana Samiah HAINGOMANANTSOA
- Transaction viewer: Mihary Nantenaina RAKOTONDRANIVO, Luchiana KILA JACQUES and Jean-Michel RAVONINJATOVO

The Atiala Atsinanana Emission Reduction Program account in the name Government of Madagascar was created at CATS level and the transfer of 1,764,499 tones ERs generated for the 2020 period was carried out in October 2023.

6.4 ERs transferred to other entities or other schemes

For the 2023–2024 period, which constitutes the final accounting period, Madagascar will deliver and sell the remaining contracted volume to the FCPF and will subsequently commercialize any remaining volume through other monetization channels.

Following comments made during the previous reporting period, the country once again confirms that the projects currently existing on the VERRA register concern projects and accounting prior to the Program. Indeed, the Makira Park and CAZ were REDD+ pilot projects and commercialized certified ERs. The Information identified on the VERRA registry concerns ERs generated from 2005 to 2013 for Makira, and from 2009 to 2012 for CAZ. Currently, there is no overlap with other programs for these two sites and both initiatives have been integrated and accounted under the Atiala Atsinanana Program for the ERPA period.

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)

There are no events to report on the risk of reversals during the 2023-2024 period, nor any reversal occurred on ERs related to the previous reporting period.

7.2 Quantification of Reversals during the Reporting Period

Not applicable because no reversals are being reported for this reporting period.
The values shown in the table below were obtained from the Excel file available at the following link (Section 7.2) : https://drive.google.com/file/d/1B0nxGtDBEz3Spu8DWBcVI8sSSWDsD0kr/view?usp=sharing

A.	**ER Program Reference level for this Reporting Period (tCO_2-e)**	*from section 4.1*		22,539,890	
B.	**ER Program Reference level for all previous Reporting Periods in the ERPA (tCO2-e).**	*from section 4.1 of previous ER Monitoring Reports*			+
C.	**Cumulative Reference Level Emissions for all Reporting Periods [A + B]**			22,539,890	
D.	**Estimation of emissions by sources and removals by sinks for this Reporting Period (tCO_2-e)**	*from section 4.2*		18,334,179	
E.	**Estimation of emissions by sources and removals by sinks for all previous Reporting Periods in the ERPA (tCO_2-e)**	*From section 4.2 of previous ER Monitoring Reports*			
F.	**Cumulative emissions by sources and removals by sinks including the current reporting period (as an aggregate accumulated since the Crediting Period Start Date) [D + E]**			18,334,179	–

G.	**Cumulative quantity of Total ERs estimated including the current reporting period (as an aggregate of ERs accumulated since the Crediting Period Start Date) [C – F]**			4,205,711	
H.	**Cumulative quantity of Total ERs estimated for prior reporting periods (as an aggregate of ERs**	*from previous ER Monitoring Reports*			–
	accumulated since the Crediting Period Start Date)				
I.	**[G – H], negative number indicates Reversals**			4,205,711	
If I. above is negative and reversals have occurred complete the following:					
J.	**Cumulative quantity FCPF ERs (as an aggregate of FCPF ERs accumulated since the Crediting Period Start Date)**	*from previous ER monitoring reports, section 8*			
K.	**Cumulative ER Program´s Pooled Reversal Buffer contributions (as an aggregate of Pooled Reversal Buffer ERs accumulated since the Crediting Period Start Date)**	*from previous ER monitoring reports, section 8*			
L.	**Cumulative ER Program´s Uncertainty Buffer contributions (as an aggregate of Uncertainty Buffer ERs accumulated since the Crediting Period Start Date)**	*from previous ER monitoring reports, section 8*			
M.	**Cumulative ER Program´s Pooled Reversal Buffer replenishments (as an aggregate of Reversal Buffer ERs replenished since the Crediting Period Start Date)**	*from previous ER monitoring reports, section 7.3*			

N.	**Cumulative amount of FCPF ERs , Uncertainty and Pooled Reversal Buffer contributions and replenishments (as an aggregate since the Crediting Period Start Date) [J + K + L + M]**			0	
O.	**Quantity of Buffer ERs to be canceled from the Pooled Reversal Buffer account [If I < N, report the value of I; if I > N, report the value of N]**			0	

7.3 Quantification of pooled reversal buffer replenishments

Not applicable because there have not been reversals in previous reporting periods.

7.4 Reversal risk assessment

Table 8 : Reversal risk assessment

Risk Factor	Risk indicators	Default Reversal Risk Set- Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk	*N/A*	**10%**	*N/A*	*10%*
Lack of broad and sustained stakeholder support	Various mechanisms aimed at defining and formalizing stakeholder support are implemented at government, initiative and communities' levels through an integrated approach. All REDD+ framework documents, including national and regional strategies, safeguards frameworks, complaints management mechanism, REDD+ decree and the benefit-sharing plan, have been drawn up and updated following consultations and validations with stakeholders at the national, regional and commune level. As the REDD+ decree, all benefit utilization plan is validated by local governance structures, ensuring that communities and stakeholders are directly involved in decision-making processes related to the benefit allocation. In addition, the safeguards framework continues to be applied and implemented, including grievance redress mechanisms, that improve transparency and help maintain stakeholder confidence and minimize risks of disengagement. The integration of REDD+ into national policies and legal frameworks ensures political support and continuity beyond project cycles, reducing the risk of disengagement. Within the State Refoundation Plan, which promotes a green and blue economy, sustainable agriculture, and renewable energy, REDD+ supports these goals by reducing emissions from deforestation and forest degradation and promoting sustainable forest management and alternative livelihoods.	**10%**	*Low risk: 10%*	0%

	REDD+ is embedded in the country's third Nationally Determined Contribution (NDC) which is currently under preparing. Forests are a major source of emissions, making REDD+ implementation a strategic lever for achieving national climate commitments. The overall objectives of REDD+ are well aligned with the Forest policy, which is structured around strategic orientations, namely: ensuring the sustainable and efficient management of Madagascar's forest capital; improving forest sector governance; and establishing sustainable financing mechanisms for the conservation and sustainable management of forest resources. The National Environmental Action Plan for Sustainable Development (PANEDD 2024–2030) adopted under decree No.26527-2024, directly supports the implementation of REDD+ program in Madagascar by integrating priority actions to address deforestation and forest degradation, which are the main sources of greenhouse gas emissions in the country. It promotes large-scale reforestation, forest landscape restoration, sustainable natural resource management, and the strengthening of carbon sinks, in line with national climate commitments. Furthermore, the PANEDD explicitly includes a REDD+ program as part of the national key and priority projects. The Madagascar 30X30 biodiversity program seeks to sustainably manage 30% of terrestrial and marine areas by 2030, aligning conservation with community prosperity and the targets of the Global Biodiversity Framework (GBF), also known as the 30x30 targets of the Convention on Biological Diversity (CBD). In order to position Madagascar as a key destination for biodiversity financing, one of the priority themes for Madagascar's biodiversity conservation, the 30x30 initiative supports the deployment of juridictional REDD+ program to generate carbon credits, thereby to reinforce REDD+ objectives and ensure that conservation efforts are closely linked with sustainable livelihoods and community prosperity.			
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	As stipulated in the REDD+ decree, the REDD+ program relies on a structured governance, characterized by the existence of a clearly mandated national coordination body, the BNCCREDD+, as well as a precise distribution of roles and responsibilities across regional levels. This is further strengthened by the establishment of formalized decision-making and validation mechanisms, contributing to the coherence and effectiveness of program steering at all levels of implementation, including the Orientation and Monitoring Committees, the Protected Area Support Committees, Local Consultation Structures, Municipal Councils, and Regional Platforms. Decentralization is ensured as regions and municipalities are fully integrated into operational processes. This integration is reflected in the effective involvement of local authorities in planning (Utilization plan), validation, implementation, and monitoring of activities. It is supported by the existence of functional local structures, such as committees and consultation platforms mentioned above, which facilitate coordination among stakeholders at the territorial level. Furthermore, the formalization of information flows between different levels of governance, through mechanisms such as regular reporting, helps ensure better coherence of interventions and smooth communication between coordinating entities, initiatives, and municipalities. The existence of a formalized system for receiving, processing, and	**10%**	*High risk: 0%*	*10%*

	monitoring complaints enables the rapid identification of institutional dysfunctions, conflicts among stakeholders, or coordination failures, and allows for appropriate corrective actions to be taken. This mechanism, which is inclusive and accessible to various stakeholders, including local communities, strengthens transparency and promotes inclusive participation in the implementation of the program. Despite the governance arrangements, the reversal risk associated with this criterion remains high, as economic pressures and underlying deforestation dynamics continue to outweigh institutional responses. Several factors felt outside the direct control of the governance framework, including: - fluctuations in vanilla prices in the SAVA and Sofia regions, which act as an aggravating factor, as price declines encourage to shift toward slash-and-burn rice cultivation; - electoral periods, which may lead to a relaxation in the enforcement of forest regulations; - the short- to medium-term nature of REDD+ results, while changes in local practices and livelihoods occur over a longer time horizon.			
Lack of long term effectiveness in addressing underlying drivers	The risks associated with slash-and-burn agriculture ("tavy") and fuelwood exploitation in Madagascar are largely driven by rural poverty. However, the Agriculture, Livestock and Fisheries Sector Program (PSAEP) aim to address these challenges by reducing poverty, improving agricultural productivity, and promoting sustainable natural resource management. Given the country's significant yet underutilized agricultural potential, the PSAEP represents a key lever for reducing pressure on forests, provided that it is implemented effectively and sustainably. The New Energy Policy 2015–2030 is also oriented toward renewable energy. This energy transition is expected to contribute to achieving the Paris climate objectives by 2050. The policy promotes the use of renewable energy and integrates REDD+ considerations through the promotion of reforestation, as well as the efficient use of fuelwood and charcoal. The commodities driving deforestation are products from permanent crops: vanilla, cloves, and coffee, high value products that are generating higher incomes to households and have a positive impact on the local economy. However, the price stability of cash crops determines their role as a buffer against deforestation, as price volatility can reverse their effect and increase reliance on slash-and-burn agriculture (tavy). An additional risk, identified through experience, is that success in the project/program areas, if associated with important positive economic impact, can lead to influx of people that are not part of the target population thus leading to unsustainable practices in the end. The ER Program aims to implement inclusive activities benefiting all populations, particularly through communes that receive rewards allocated to infrastructure and social services for the benefit of a large number of people. However, due to limited financial resources, the use of these revenues remained constrained and did not fully cover all targeted beneficiaries. This situation may lead, in areas not directly benefiting from program activities, to the adoption of unsustainable practices as a response to ongoing economic constraints. Is relevant legal and regulatory environment conducive to REDD+	**5%**	*High Risk: 0%*	*5%*

	objectives? The National Spatial Planning Policy (PNAT) seeks to promote efficient and sustainable management of the national territory. Its main objective is to rationalize and improve the management and valorization of natural resources. This is achieved through the systematic integration of environmental and climate change considerations into all spatial planning actions, across all sectors and at every level. The mining sector has also adopted several regulatory texts emphasizing the need to preserve the environment while developing the sector. One of the key objectives of the Mining Policy framework integrates the dimension of sustainable natural resource management and biodiversity conservation in the protected areas.			
Exposure and vulnerability to natural disturbances	The risk of natural disturbances leading to significant forest loss in the project area is considered very low and effectively controlled, based on the following evidence: Forest fires: The project area is located in humid rainforest ecosystems where natural fires are virtually non-existent. In Madagascar, large-scale fires are predominantly observed in dry and savannah ecosystems, not in humid forests. Available literature confirms that fires in eastern rainforests are almost exclusively of anthropogenic origin rather than natural causes. Furthermore, a strong regulatory framework is in place, including Ordinance 60-127 on vegetation clearing and fire management, complemented by fire prevention and response strategies within protected areas. A permanent fire monitoring and evaluation committee is established at the level of each Sub-prefecture headquarters in accordance with Decree No. 2002-793 defining incentive measures for the prevention and eradication of bush fires. Pests and diseases: There is no historical evidence of major pest or disease outbreaks causing large-scale forest dieback in Madagascar's humid forests. The ecological characteristics of tropical rainforests—high species diversity and low species dominance—naturally limit the risk of widespread infestation. This risk is further mitigated by the existence of Ordinance 86-013 on phytosanitary legislation, and ongoing efforts by relevant ministries to strengthen preventive and curative phytosanitary frameworks adapted to forest ecosystems. Extreme climate events (cyclones): Cyclones are the main extreme climatic events affecting eastern Madagascar. However, available data do not indicate significant or lasting forest loss attributable to cyclones. While cyclones may cause localized damage, they have not been identified as a driver of deforestation. Additionally, resilience is reinforced through national adaptation strategies, including the promotion of native species reforestation under the National Adaptation Plan, which enhances forest resistance to extreme weather events. Integrated mitigation under REDD+: Prevention and mitigation measures related to natural disturbances are fully integrated into Strategic Orientation No. 3 of the National REDD+ Strategy, ensuring continuous monitoring, risk management,	**5%**	*Medium risk: 2%*	*3%*

	and adaptive responses.			
.		**Total reversal risk set-aside percentage**		*28%*
		Total reversal risk set-aside percentage from previous monitoring report		28%

8. EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

The values shown in the table below were obtained from the Excel file available at the following link (Section 8) :
https://drive.google.com/file/d/1B0nxGtDBEz3Spu8DWBcVI8sSSWDsD0kr/view?usp=sharing

Table 9 : ERs available for transfer to the Carbon Fund

	Year		**2023**	**2024**	**Total**
A.	**Emission Reductions during the Reporting period (tCO_2-e)**	*from section 4.3*	2,106,755	2,098,955	4,205,710
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	0	0
C.	**Number of Emission Reductions estimated using Measurement approaches (A-B)**		2,106,755	2,098,955	4,205,710
D.	**Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested**	*from section 6.1*	100%	100%	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	0	0
	If applicable, any buffer replenishments	*section 7.3 P*	0	0	0
F.	**Total ERs [(B+C)*D-E] minus, if applicable, any replenishments as per section 7.3, P**		2,106,755	2,098,955	4,205,710

G.	**Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period**	*from section 5.2*	12%	12%	
H.	**Quantity of ERs to be allocated to the Uncertainty Reversal Buffer (0.15*B/A*F)+(G*C/A*F)**		252,811	251,875	504,685
I.	**Total Reversal Risk set-aside percentage applied to the ER program**	*from section 7.4*	28%	28%	
J.	**Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*I**		519,104	517,182	1,036,287
K.	**Number of FCPF ERs (F- H – J)**		1,334,840	1,329,898	2,664,738
L.	**Percentage of Emission reductions from enhanced Removals from afforestation/reforestation as a percentage of the total FCPF ERs [Optional if the country wishes to generate enhanced Removals]**	*From section 4.3*	0.00000000%	0.00000000%	
M	**Number of FCPF ERs from enhanced Removals from afforestation/reforestation (L * K) [Optional if the country wishes to generate enhanced Removals]**		0	0	

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

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

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

ANNEX 5: DETAILED DESCRIPTION OF THE APPLICATION OF THE REVERSAL RISK ASSESSMENT TOOL

Document history

Version	Date	Description
3.2	September 2025	Tables in sections 4, 8 and 8.4 (annex 4) have been adjusted to reflect the latest updates to the FCPF ER-MR template tool.
3.1.2	March 2025	Requirements for HFLD labelling were added to the template.
3.1.1	July 2024	• The frontpage table and Sections 7 and 8 have been revised to reflect the provisions of the Buffer Guidelines version 4.2, namely: ◦ The changes made to the equation applied to estimate the amount of Pooled Reversal Buffer ERs that should be cancelled in case of a Reversal; ◦ The merge of Reversal Buffers and the Pooled Reversal Buffer; and ◦ The recognition that not only the ERs transferred to the Carbon Fund may suffer Reversals. • Section 1.3 has been included to allow the reporting of approved material or non-material methodological deviations. • Section 2.2 has been included to allow ER Programs to report any updates to the validated monitoring plan.
3.1	July 2024	• Annex 2 was updated for the reporting of the BSP implementation, for countries that have received ER payments. Countries should provide evidence on whether the BSP has been implemented in accordance with the terms of the agreed BSP. • Annex 3 was adjusted for a better guidance on the reporting of Non-Carbon Benefits.
3	February 2024	Version approved virtually by Carbon Fund Participants. Changes made: • Sections 4.3 and section 8 were adjusted to be able to report ERs from Removals separately • Annex 5 was included to provide a detailed report on the application of the Reversal Risk Assessment Tool
2.5	May 2023	• Section 4.3 has been revised to provide guidance on how to consider non-performance or Reversals from previous periods

		• Section 5.2 has been revised to clarify that the cumulative Uncertainty during the Crediting Period may be calculated based on propagation of errors, not montecarlo
2.4	May 2022	• Page 1 and section 8 have been adjusted to reflect the definition of Total ERs
2.3	December 2021	• Section 5.2 was adjusted to allow the reporting of the Uncertainty estimates for both the Reporting Period and the Crediting Period. • Section 8 has been adjusted to clarify that countries can also report ERs jointly and not only in separate calendar years.
2.2	August 2021	• Cross-references have been corrected • Information about the start date of the Crediting Period has been requested in annex 4.
2.1	November 2020	Aspects on Uncertainty analysis were revised based on the Guidelines on Uncertainty analysis.
2	June 2020	Version approved virtually by Carbon Fund Participants. Changes made: • Update to consider the changes made to the Methodological Framework (Version 3.0) and Buffer Guidelines (Version 2.0) • Update to consider the changes made to the Validation and Verification Guidelines
1	January 2019	The initial version approved by Carbon Fund Participants during a three-week non-objection period.