

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

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

|                                                                                       |                                                                                  |
|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| <b>ER Program Name and Country:</b>                                                   | Emission Reduction Program in Atiala Atsinanana (ERP-AA), Republic of Madagascar |
| <b>Reporting Period covered in this report:</b>                                       | From 01/01/2021 to 31/12/2022                                                    |
| <b>Number of FCPF ERs:</b>                                                            | 11,019,109                                                                       |
| <b>Quantity of ERs allocated to the Uncertainty Buffer:</b>                           | 637,679                                                                          |
| <b>Quantity of ERs to allocated to the Pooled Reversal Buffer:</b>                    | 4,285,208                                                                        |
| <b>Number of FCPF ERs from enhanced removals through afforestation/ reforestation</b> | 0                                                                                |
| <b>Date of Submission:</b>                                                            | 28-06-2024                                                                       |
| <b>Version</b>                                                                        | 6.2                                                                              |

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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 Committee of the Protected Area           |
| DD        | : | Deforestation and Forest Degradation                                 |
| DGGE      | : | Directorate General of Environmental Governance                      |
| 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                               |
| MAEP      | : | 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                     |
| OSC     | : | Civil Society Organization                                   |
| PA      | : | Protected Area                                               |
| PADAP   | : | Sustainable Agriculture Project through a Landscape Approach |
| 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 2020 period, two major advances are reported with regard to the Program:

- In October 2021: the REDD+ decree was adopted by the Government Council, stipulating all implementation frameworks and the applicable financial mechanism: (<https://www.environnement.mg/?wpdmpo=decret-relatif-a-la-regulation-de-laces-au-marche-de-carbone-forestier#>)
- In July 2022: the decree on the Treasury's special allocation account (CAS) was adopted by the Government Council, enabling the account to receive REDD+ payments.
- From 2022 and on: Activities related to MRV 1 and the ER Monitoring reporting for 2020 are underway

No REDD+ payments have been disbursed during the second reporting period (2021-2022) as the transfer of ERs and the first payment only occurred in the last quarter of 2023. In other words, the Program's activities during the 2021-2022 period were financed by investments made by actors within the Program:

- 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/1q\\_u7wRi6\\_PhY9oOILLUFXc1MbrMt368?usp=drive\\_link](https://drive.google.com/drive/folders/1q_u7wRi6_PhY9oOILLUFXc1MbrMt368?usp=drive_link)

### Details of activities implemented:

|                                                                                                                                                                                                                                                                                                                                                          |                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| <b>Generic activities :</b> <ul style="list-style-type: none"><li>- Activities supervision and monitoring</li><li>- Prioritization and programming of Protected Area activities</li><li>- Demarcation and maintenance of PA boundaries</li><li>- Strengthening and maintenance of ecotourism infrastructures</li><li>- Control of forest fires</li></ul> | Under the 15 REDD+ initiatives |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|



**Updating the PA Development and Management Plan and management tools**

Under the COMATSA PA  
Ongoing implementation under the 14 other initiatives

**Strengthening local governance: support and capacity building for the PA Steering Committee (COS and COSAP)**

Under the 15 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**

COMATSA PA 392 patrols  
 CAZ PA 4 132 patrols  
 Mahimborondro PA 410 patrols  
 Marotandrano PA 176 patrols  
 Ambatovaky PA 854 patrols  
 Mantadia and Analamazaotra PA 1224 patrols  
 Anjanaharibe Sud and Marojejy PA 1803 patrols  
 Mananara PA 698 patrols  
 Betampona PA 243 patrols  
 Mangerivola PA 295 patrols  
 Masoala PA 1 686 patrols  
 Zahamena PA 869 patrols



**Restoration/Reforestation**

Active retsoration :  
 COMATSA PA 163 218 Ha  
 CAZ PA 1640 Ha  
 Mahimborondro PA 410 patrols  
 Marotandrano PA 176 patrols  
 Ambatovaky PA 854 patrols  
 Mantadia and Analamazaotra PAs1224 patrols  
 Anjanahanaribe Sud and Marojejy Pas 1803 patrols  
 Mananara PA 698 patrols  
 Betampona PA 243 patrols

|  |                                                                                   |
|--|-----------------------------------------------------------------------------------|
|  | Mangerivola PA 295 patrols<br>Masoala PA 1 686 patrols<br>Zahamena PA 869 patrols |
|--|-----------------------------------------------------------------------------------|



|                                                       |                                |
|-------------------------------------------------------|--------------------------------|
| Ecological monitoring for conservation target species | Under the 15 REDD+ initiatives |
|-------------------------------------------------------|--------------------------------|



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|-----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Implementation of Information, Awareness and Education Programs | <ul style="list-style-type: none"> <li>- Radio programs under the COMATSA PA</li> <li>- Collaboration with CISCO for environmental education in 35 schools and radio and TV broadcasts under the Makira PA</li> <li>- Development and distribution of information sheets and leaflets in Malagasy under the CAZ PA</li> </ul> |
|-----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|  |                                                                                                               |
|--|---------------------------------------------------------------------------------------------------------------|
|  | <ul style="list-style-type: none"> <li>- Community mobilization campaigns under the 15 initiatives</li> </ul> |
|--|---------------------------------------------------------------------------------------------------------------|



|                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Alternatives to deforestation and income-generating activities</b> | <ul style="list-style-type: none"> <li>- Establishment of community savings groups as funds for community livelihood activities</li> <li>- Reinforcement of rice-growing intensification techniques and provision of agricultural equipment under Makira, CAZ and COMATSA PA's</li> <li>- Implementation of dynamic agroforestry under Makira (cocoa, cloves and vanilla), Mahimborondro (vanilla), CAZ (coffee and cloves)</li> <li>- Apiculture (Bee-keeping) under Mahimborondro PA</li> <li>- Integrated fish and chicken breeding (chicken farming and fish farming) under Makira</li> <li>- Support for food crop production (seed supply)</li> </ul> |
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#### Value chain and market promotion

- Establishment of the MIARO Cooperative, bringing together producers under the CAZ PA.
- Studies carried out under Makira, including a study on the in-depth analysis of the cocoa value chain and export mechanism; a study on the development of a business plan for the two cooperatives COPROCAVOL and KAJIVOLA.
- Cocoa chain: Setting up a fermentation center and a bean drying complex under the Makira PA
- Market opportunities study for value chains and market system analysis
- Linking communities with private operator Symrise for vanilla production under Marojejy PA



#### Support for improved access to healthcare and education

- Mobile clinic missions with the health department and provision of hygiene and antigenic kits for schools under the Makira PA in the context of coronavirus.
- Provision of school equipment and kits under the Mahimborondro PA



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

Monitoring during the 2020 period showed that there were no leaks around the Program area. Analyses of displacement pressures remain relatively unchanged for the 2021-2022 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 Mahimborondro, 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, Mahimborondo 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.

Specifically, to Tsaratanàna forest, Monitoring and forest control activities are carried out by the communities, MNP and the forces. On average, 100 patrols per year are carried out in the entire zone. At the same time, awareness-raising activities have been carried out among local authorities and villagers, with 726 beneficiaries during the period.

### ***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 of the Program's structures in the 5 regions have already been set up in 2020 and strengthened in terms of equipment and capacity to enable the delegation of part of the Program's management to the five implementing regions. With regard to the operational management of REDD+ activities, the six initiative promoters ensure the supervision and technical and financial support of field actors in intra-initiative activities, as well as monitoring and reporting on the implementation of REDD+ activities. As this responsibility is already established with the forestry administration, there are no major difficulties in operationalizing the institutional arrangements. For the 2022 period, significant progress concerns the start-up of capacity building in REDD+ management and complaint handling in the SAVA Region.

As part of the process of identifying new promoters to strengthen the program, two new potential protected areas have been identified in the program area:

- Torotorofotsy, with a forest cover of approximately 8,100 ha and an annual deforestation rate of 0.57%, managed by the NGO Asity Madagascar; and
- The Mangabe-Ranomena-Sahasarotra complex, with a forest cover of approximately 7,400 ha and an annual deforestation rate of 0.45%, managed by the NGO Madagascar Voakajy.

The two potential new protected areas will be validated as REDD+ Initiatives under the program if they meet the required criteria based on the initial investment made, the existence of local governance that brings together the actors involved in the PA's activities, and the implementation of environmental and social safeguards.

### ***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***

Although the Program's financing plan was to be funded jointly by the initial promoters' investments and first REDD+ payment, unfortunately no REDD+ payments have been disbursed for the Program during 2021-2022.

Initially, the Program was supposed to benefit from an upfront advance (2 Millions USD) that would be used for an emergency response to deforestation issues awaiting the regular payments generated by the Program but the fund could not be cashed in because the REDD+ decree was only adopted in October 2021, and the decree on treasury's special allocation account (CAS REDD+) intended to receive the funds was adopted in 2022. Consequently, the efforts of each side of the initiatives made it possible to maintain the activities of the Program.

## **1.2 Update on major drivers and lessons learned**

A Field survey was conducted in the ER Program Atiala Atsinanana including the five (05) Regions of the Program during the Year 2023. The objective of the field survey was mainly to collect data to determine the evolution of the causes of the loss of forest cover. The synthesis of the results of the field survey are seen in the next table:

**Table 1 : Drivers of deforestation and forest degradation in the Atiala Atsinanana Emissions Reduction Program area for the 2021-2022 monitoring period**

| <i>Type of Driver</i>                             | <i>Results of LOFM studies (data collection on 2021 for MNV 1)</i>                                                                                                                                                                                                                                   | <i>Results of LOFM studies (data collection on 2023 for MNV 2)</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <i>Examples of the regions concerned in the Program (data collection on 2023 for MNV 2) (Reports and interview results seen in: <a href="https://drive.google.com/file/d/1eJVxq6LdP8libYBjqxlPYkEkaHdcPeVo/view?usp=drive_link">https://drive.google.com/file/d/1eJVxq6LdP8libYBjqxlPYkEkaHdcPeVo/view?usp=drive_link</a>)</i> |
|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Transport infrastructure and accessibility</b> | 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.)<br>The low accessibility of forests often concentrates pressures in remote and/or very localized areas.<br>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.<br>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 | SAVA, Sofia, Alaotra Mangoro                                                                                                                                                                                                                                                                                                   |

|                        |                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |
|------------------------|----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
|                        |                                                                                                    | <p>illustrate the phenomenon.</p> <p>For the Analanjirofo Region, in the Districts 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).</p> |                                          |
| <b>Mines</b>           | In 2020, mining was classified as a significant driver of deforestation and/or forest degradation. | <p>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.</p> <p>The cases of Makira and Anjanaharibe Sud in the SAVA Region are an example of this phenomenon. The Alaotra Mangoro Region is also concerned.</p>                                                                                                                                                                                                                                                                                        | SAVA; Alaotra Mangoro                    |
| <b>Permanent crops</b> | As results for the study on 2021, permanent crops are responsible for                              | In 2021 and 2022, permanent crops are still a significant driver of                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | SAVA, Sofia, Alaotra Mangoro, Atsinanana |

|                     |                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |             |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
|                     | <p>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.</p> <p>.</p>            | <p>Deforestation and Degradation.</p> <p>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.</p> <p>In Analanjirofo, the permanent cultivation of vanilla is practiced, promoting 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.</p> <p>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.</p> |             |
| <b>Annual crops</b> | <p>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”.</p> | <p>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</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Sofia, SAVA |

|                                       |                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                        |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
|                                       |                                                                                                                                                                                                                                                                                                                 | <p>sometimes a blocking factor in lowland cultivation.</p> <p>The Andapa District, for example, is one of the major rice producers in SAVA. Crops are found on both lowlands and “tanety”.</p> <p>Generally, it is a “practice”, an “habit”.</p>                                                                                                                                                                                                                                                                                                                                              |                                                        |
| <b>Livestock</b>                      | <p>In 2020, livestock farming is not classified as a factor or driver of deforestation or degradation in the PRE AA-Program area.</p>                                                                                                                                                                           | <p>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.</p> <p>In the SAVA Region, livestock farming has no direct impact or influence on the pressure on the forest.</p> <p>For Analanjirofo and Atsinanana, breeding also certainly has no effect.</p> <p>Thus, livestock farming cannot be listed as a driver of deforestation or degradation.</p> | N/A                                                    |
| <b>Commercial timber exploitation</b> | <p>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.</p> | <p>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</p>                                                                                                                                                                                            | SAVA, Sofia, Atsinanana, Alaotra Mangoro, Analanjirofo |

|                                                               |                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                   |
|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
|                                                               |                                                                                                                                                                           | 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.                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                   |
| <b>Exploitation of non-marketed fuelwood and service wood</b> | 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.                                                                                                                                                                                                                                                                                                                                                                                              | N/A                               |
| <b>Carbonization</b>                                          | 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.<br>On the other hand, in 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.<br>Carbonization is also not a driver of Deforestation and Degradation in the Analanjirofo Region where the population instead uses dead wood. | Atsinanana, Sofia                 |
| <b>Fires</b>                                                  | 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | SAVA, Atsinanana, Alaotra Mangoro |

|                         |                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                               |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
|                         |                                                                                                                                                                | <p>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 Degradation.</p> |                                                               |
| <b>Demography</b>       | <p>Migration phenomena generated significant deforestation because migrants resort to illegal artisanal mining, the practice of tavy, and illegal logging.</p> | <p>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.</p>                                                                                                                                                               | <p>Alaotra Mangoro, Analanjirofo, Atsinanana, Sofia, SAVA</p> |
| <b>Economic context</b> | <p>In 2020, the isolation and low education of the population would be partly responsible for deforestation and forest degradation.</p>                        | <p>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</p>                                                                        | <p>Analanjirofo, SAVA</p>                                     |

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | exploit forest land for the cultivation of rice and cloves.<br>The economic context greatly influences land use, and therefore increases deforestation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |
| <b>Technology</b> | 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 performance. | 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 cultivation. | Analanjirofo, SAVA |

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) versus the current reporting period 2021-2022, 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 2021 and 2022, migration is 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:

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

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

- 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 2021 and 2022.

- 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 is still remaining in 2021 and 2022.

- 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 2021 and 2022, 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 is the same during the monitoring period: 2021 and 2022.

- **Environmental Suitability:**

The localization of deforestation is 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.

As remark, in the years 2021 and 2022, the deforestation observed are primarily in the “green belt” of the Protected Areas, and also inside Protected Areas where the monitoring and control is almost inexistant or inexistant. At the same time, there is a degradation observed in the zones where the natural resources are concentrated (illustrated by the presence of sites of illegal mining inside the Protected Areas) and also the cutting of precious woods which are not controlled).

We can also note that according to the report for the monitoring period 2020, all drivers are linked and exacerbated by poverty. With the data collected for 2021 and 2022, we can say that not only poverty explains the existence and development of these drivers but also corruption, lack of organization between the institutional structures which have the role of monitoring, and controlling the utilization of the resources and the respect of the zonings of the Protected Areas.

### **1.3 Methodological deviations**

Some errors were found in the validated Reference Level when preparing the second monitoring report. These errors pertain to the incorrect integration of emission factors in the excel file for the emission factors pertaining to the AGB for secondary forest, agroforestry, and plantations.

Here's the link to the Excel file for MR1, with the error highlighted in yellow for the Reference level and Biomass cell (link :

[https://docs.google.com/spreadsheets/d/16R6AzitWpnH2qbB0IHKSndswEoBYuBym/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/16R6AzitWpnH2qbB0IHKSndswEoBYuBym/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true) ). The correction is shown in the excel file for MR2 still highlighted in yellow for these two cells (link :

[https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true)

)

Moreover, a mistake was found in the formula calling to the root to shoot ratio of plantations. The corrections resulted in a slightly increase of the reference level. See below:

| Years | REFERENCE LEVEL |            | Difference |
|-------|-----------------|------------|------------|
|       | Before          | After      |            |
| 2020  | 11,849,654      | 11,884,044 | (34,390)   |
| 2021  | 11,836,401      | 11,870,790 | (34,389)   |
| 2022  | 11,823,147      | 11,857,536 | (34,389)   |
| 2023  | 11,809,893      | 11,844,282 | (34,389)   |
| 2024  | 11,796,639      | 11,831,028 | (34,389)   |

The errors described above are material given that they represent 1% of the gross and total FCPF units as can be seen in the excel file (example\_sections\_7.2\_7.3 and \_8\_mr\_template\_july2024\_v7.0, tab adjustments), link : [https://docs.google.com/spreadsheets/d/1pOO-hJPtKJLgrc1iqoGf\\_MxqGrvFYb9/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pOO-hJPtKJLgrc1iqoGf_MxqGrvFYb9/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true) and below :

| Materiality |                   | ERs       | Percentage % |
|-------------|-------------------|-----------|--------------|
|             | Net FCPF (before) | 1,764,499 | 100          |
|             | Difference        | 17,787    | 1            |
|             | Gross (before)    | 2,663,795 | 100          |
|             | Difference        | 26,853    | 1            |

The MF guidance related to materiality can be found in the link : [fcpf\\_guidelines\\_on\\_uncertainty\\_analysis\\_2020\\_0.pdf](#) on page 3, paragraph 2, number 18.

The links to the files showing the materiality and the links for calculating the difference are shown in the following link :

[https://docs.google.com/spreadsheets/d/1vtCSFMAF0ybRMAceKt0bgl3FJ8S13Rz5/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1vtCSFMAF0ybRMAceKt0bgl3FJ8S13Rz5/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true)

the sheet highlighted in green shows the difference.

To avoid these errors from happening again, the MRV team will perform a thorough review before finalizing the subsequent monitoring report to ensure that all cells in the estimation tools are correctly linked to the appropriate factors.

## 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 |  | <p>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.</p> <p>The monitoring system is based on the following key elements:</p> |

|  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  | <p>▪ 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.</p> <p>The BNCCREDD+ assumes overall responsibility for future land use change assessment and ERP monitoring report development.</p> <p>*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</p> <p><b>Methodology Division</b></p> <p><b><u>Roles and responsibilities</u></b></p> <ul style="list-style-type: none"> <li>- Design, implement and ensure the realization of national forest inventory methodologies</li> <li>- Ensure the implementation of Greenhouse gas inventories for the forestry sector</li> <li>- Establish the calculation methods of the Forests Reference Emission Levels (FREL) and proceed to their evaluation</li> <li>- Establish the methodological standards for the determination of Emission Factors and make the calculations</li> <li>- Ensure the measurement of carbon performance at the scale of REDD+ Programs and Initiatives</li> <li>- Participate in the calculation and reporting of carbon performance based on a transparent and reliable methodological process in coordination with the LOFM</li> </ul> <p><b>Madagascar Forest Observation Laboratory Division (LOFM)</b></p> <p><b><u>Roles and responsibilities</u></b></p> <ul style="list-style-type: none"> <li>- Ensure cartographic production and generation of forest statistics with protocols and manuals for each process</li> <li>- Ensure the adoption of the Land Use and Occupancy classification systems and forest definitions as national standards</li> <li>- Develop, formalize and popularize standard tools for monitoring forest cover (national grid...) and their guides for use by third parties</li> <li>- Have a cartographic database/metadata, satellite images, statistics, reports</li> <li>- Develop and implement the Satellite Land Monitoring System</li> <li>- Collect, ensure and control the quality of data on land use change and forest area, and perform analyses</li> <li>- Conduct spatial analyses including descriptive causes of deforestation and degradation</li> <li>- Monitor changes in national forest cover, at administrative scales as needed (deforestation rate per Commune ...) and in Programs and Initiatives</li> </ul> |
|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

- 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 ([https://drive.google.com/file/d/1ySgscvtfmb\\_tDvmdKFZNhIrSy7sbU\\_5m/view?usp=sharing](https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhIrSy7sbU_5m/view?usp=sharing))
- The SOP on sampling (<https://drive.google.com/file/d/1fNh6rQ8XL48Y9m6Sj3hLtL7U4Q-OXI9K/view?usp=sharing>)
- The SOP on data interpretation (response system) ([https://drive.google.com/file/d/1Hs3BSGL69kK6\\_ELrvq5h5-\\_lOpDZtJTS/view?usp=sharing](https://drive.google.com/file/d/1Hs3BSGL69kK6_ELrvq5h5-_lOpDZtJTS/view?usp=sharing))
- The SOP on data collection ([https://drive.google.com/file/d/1Qf4PIgJvX03cISYtpbhC9\\_HboXIRP1go/view?usp=sharing](https://drive.google.com/file/d/1Qf4PIgJvX03cISYtpbhC9_HboXIRP1go/view?usp=sharing))
- The SOP on data Analysis ([https://drive.google.com/file/d/1\\_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing](https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing))

(Link to FCPF forms: [https://drive.google.com/file/d/1ziRgEpZqB-buNmrc2\\_Xs8YoPFyOyg\\_PH/view?usp=sharing](https://drive.google.com/file/d/1ziRgEpZqB-buNmrc2_Xs8YoPFyOyg_PH/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+.

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.

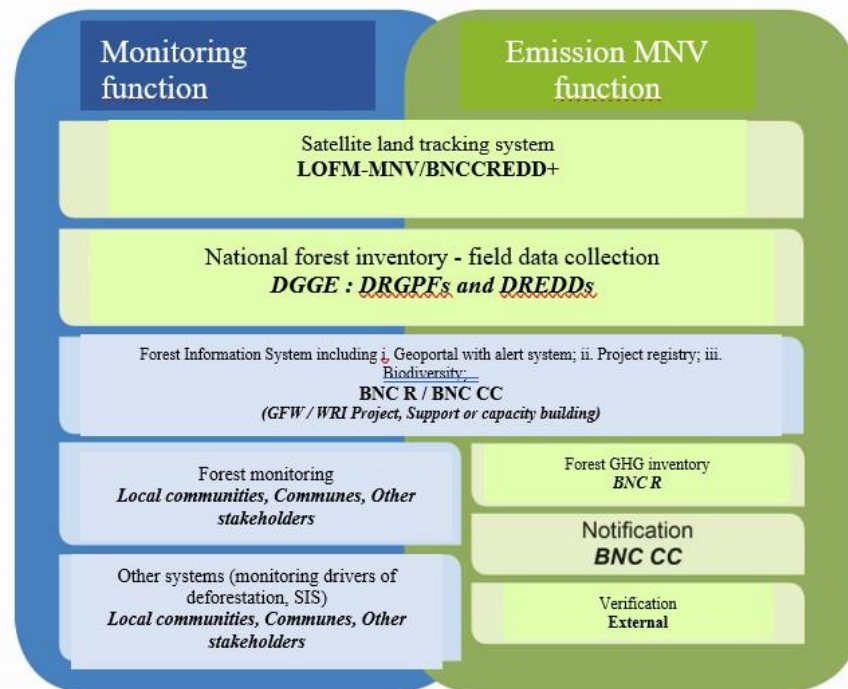
Community-based monitoring activities exist in areas where government presence is weak.

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.

|                                                                    |                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------------------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                    |                                                                                      | <p>BNCCREDD+ prepares and compiles the results of the measurement, monitoring and reporting activities into the monitoring report submitted to the FCPF for external verification.</p> <p>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.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <p><b>Selection and management of GHG data and information</b></p> | <p>Methods and standards for data generation, storage, aggregation and reporting</p> | <p>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.</p> <p>These monitoring data can be found in the following documents :</p> <ul style="list-style-type: none"> <li>- Legal documents (title transfer and access to the Carbone revenue)</li> <li>- Safeguards documents</li> <li>- MRV documents</li> <li>- Land use map and processes</li> <li>- Activity data and map</li> </ul> <p>(in the MNV Standard tab), which is an inherent part of the NFMS.</p> <p>Inventory results are stored in the same way. This approach ensures that the data is stored and is publicly available.</p> <p><b><u>Structure of the NFMS</u></b></p> |

The MRV function of the NFMS is strictly related to the estimation, reporting and verification of GHG emissions and removals.



#### 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.

|                                                                                                                                                                                                                                             |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                             |  | <p>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).</p> <p>This was done through four main principles:</p> <ul style="list-style-type: none"> <li>▪ 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);</li> <li>▪ 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);</li> <li>▪ Emission factors (EFs) and default values: The same EFs and default values used for the RL were used in the estimation of GHG emissions by sources and removals by sinks (CF MF Indicator 14.3);</li> <li>▪ GHG accounting: the same equations, calculation procedures, and QA/QC as used for the RL were used (CF MF Indicator 14.1).</li> </ul> <p>The only parameters being changed with respect to the RL are the activity data.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <p><b>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</b></p> |  | <p>The overall measurement, monitoring, and reporting process includes all Earth Observation (EO) data collection operations, Quality Assurance (QA) operations, and final reporting.</p> <p>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.</p> <p>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 the information on the web (BNCCREDD website). The system and processes that support the Forest Monitoring System are in place:</p> <ul style="list-style-type: none"> <li>- Satellite Land Monitoring System</li> <li>- MRV</li> </ul> <p>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:</p> <ul style="list-style-type: none"> <li>-The SOP on stratification map creation (<a href="https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhIrSy7sbU_5m/view?usp=sharing">https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhIrSy7sbU_5m/view?usp=sharing</a>)</li> <li>-The SOP on sampling (<a href="https://drive.google.com/file/d/1fNh6rQ8XL48Y9m6Sj3hLtL7U4Q-OXl9K/view?usp=sharing">https://drive.google.com/file/d/1fNh6rQ8XL48Y9m6Sj3hLtL7U4Q-OXl9K/view?usp=sharing</a>)</li> <li>-The SOP on data interpretation (response system) (<a href="https://drive.google.com/file/d/1Hs3BSGL69kK6_ELrvq5h5-_lOpDZtJTS/view?usp=sharing">https://drive.google.com/file/d/1Hs3BSGL69kK6_ELrvq5h5-_lOpDZtJTS/view?usp=sharing</a>)</li> <li>-The SOP on data collection (<a href="https://drive.google.com/file/d/1Qf4PIgJvX03clSYtpbhC9_HboXIRP1go/view?usp=sharing">https://drive.google.com/file/d/1Qf4PIgJvX03clSYtpbhC9_HboXIRP1go/view?usp=sharing</a>)</li> <li>-The SOP on data Analysis (<a href="https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing">https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing</a>)</li> </ul> <p>Each POS has its own objective, namely:</p> <ul style="list-style-type: none"> <li>-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.</li> <li>-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.</li> <li>-The SOP on the forest inventory guidelines (<a href="https://drive.google.com/file/d/1AGrybPnC5Z4Xoxlb-HA_Z5c_q7m6UJoV/view?usp=drive_link">https://drive.google.com/file/d/1AGrybPnC5Z4Xoxlb-HA_Z5c_q7m6UJoV/view?usp=drive_link</a> and <a href="https://drive.google.com/file/d/11kTLBR1Me7KAp8j7F4UOdNkuTSGWaMsh/view?usp=drive_link">https://drive.google.com/file/d/11kTLBR1Me7KAp8j7F4UOdNkuTSGWaMsh/view?usp=drive_link</a>)</li> <li>-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</li> </ul> |

|                                                                                                                                                           |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                           |  | <p>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.</p> <p>- 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.</p> <p>QA/QC procedures are applied, specifically for the collection and updating of activity data, namely:</p> <p>- 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 (<a href="https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhlsy7sbU_5m/view?usp=sharing">https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhlsy7sbU_5m/view?usp=sharing</a> 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 (<a href="https://drive.google.com/file/d/1Qf4PIgJvx03clSYtpbhC9_HboXIRP1go/view?usp=sharing">https://drive.google.com/file/d/1Qf4PIgJvx03clSYtpbhC9_HboXIRP1go/view?usp=sharing</a> ).</p> <p>- During data analysis: The Laboratory and Methodology Manager, in coordination with the analysts, checks that the calculations comply with SOP number 4 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 ... ) (<a href="https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing">https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing</a> ).</p> <p>The forest inventory guidelines are available on these links : (<a href="https://drive.google.com/file/d/1AGrybPnC5Z4Xoxlb-HA_Z5c_q7m6UJoV/view?usp=drive_link">https://drive.google.com/file/d/1AGrybPnC5Z4Xoxlb-HA_Z5c_q7m6UJoV/view?usp=drive_link</a> ) and (<a href="https://drive.google.com/file/d/11kTLBR1Me7KAp8j7F4UOdnKuTSGWaMsh/view?usp=drive_link">https://drive.google.com/file/d/11kTLBR1Me7KAp8j7F4UOdnKuTSGWaMsh/view?usp=drive_link</a> )</p> |
| <b>The role of communities in the Forest Monitoring System;</b>                                                                                           |  | <p>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...</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>The use of and consistency with technical procedures operational in the country, and their consistency with the National Forest Monitoring System.</b> |  | <p>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.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

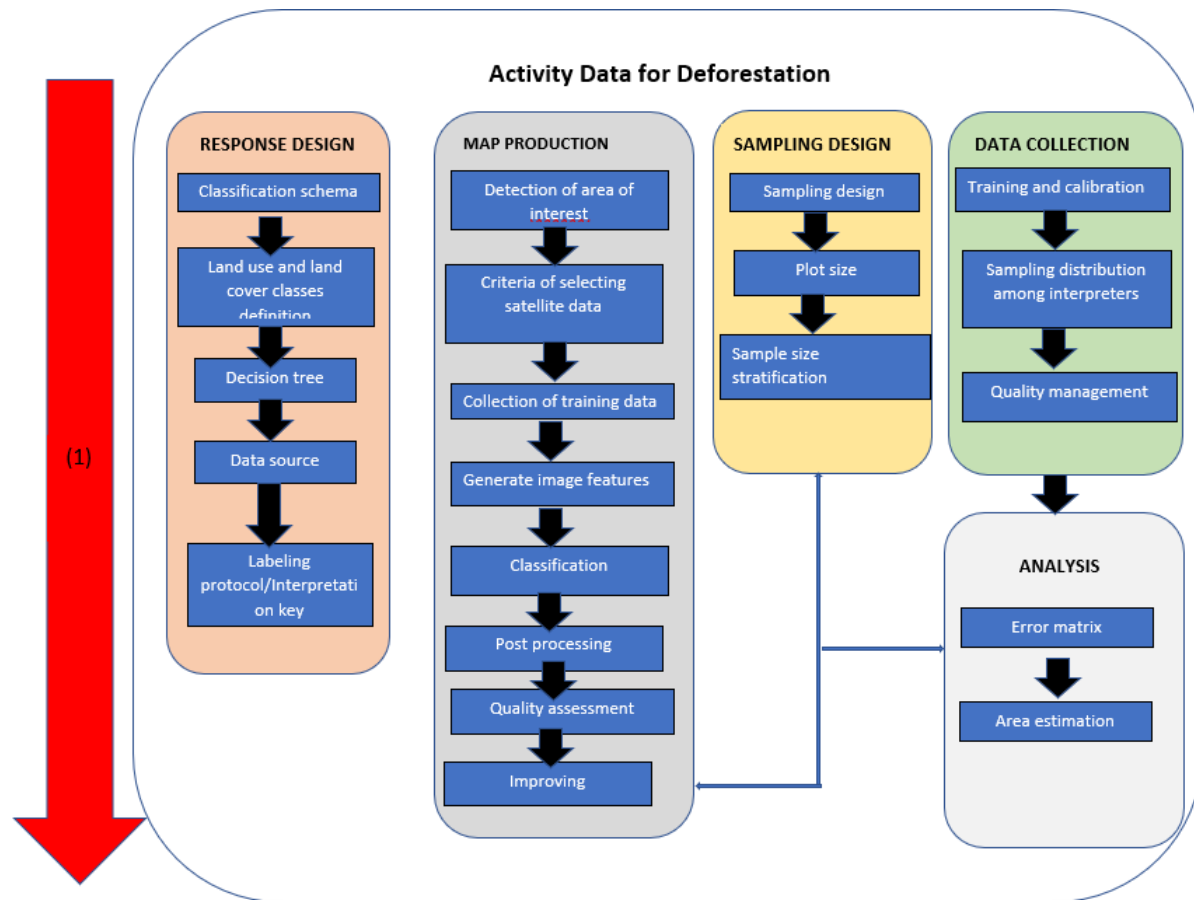
## 2.2 Updates to the monitoring approach

For this monitoring period (2021-2022), 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+.



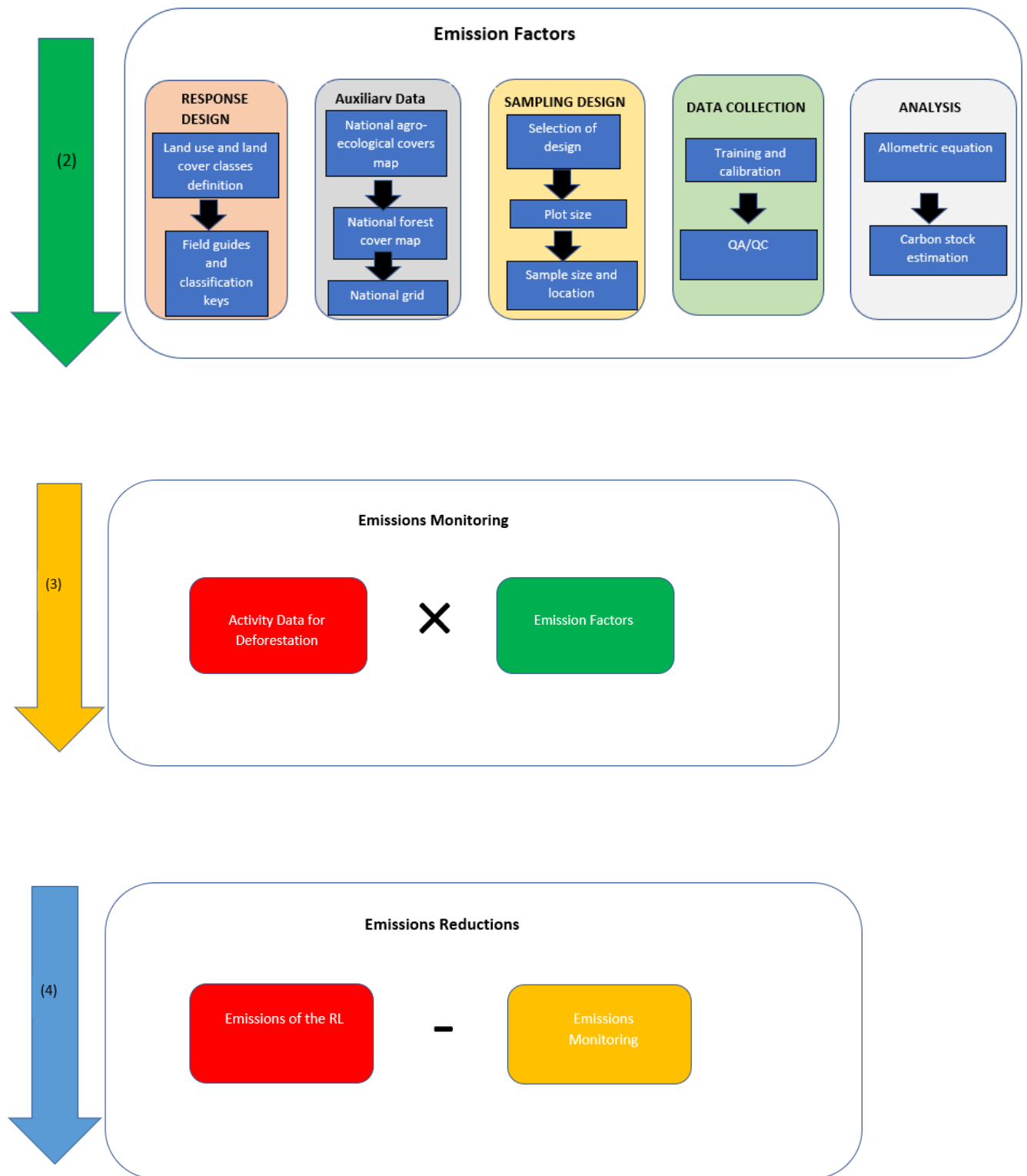


Figure 1 : Workflow on emission reduction calculation

### 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 : Calcul RE :

[https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&oid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&oid=112106790342798073832&rtpof=true&sd=true)

Biomasse Madagascar :

[https://docs.google.com/spreadsheets/d/1vSxK577AX1WNDap0K8CbYtCGgoDT6OIV/edit?usp=drive\\_link&oid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1vSxK577AX1WNDap0K8CbYtCGgoDT6OIV/edit?usp=drive_link&oid=112106790342798073832&rtpof=true&sd=true)

The data used comes from the traitement 2020 sheet.

#### 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**

| <i>Source/Sink</i>                  | <i>Pool</i>                                | <i>Methods</i>                                                       | <i>Tier</i>                                     |
|-------------------------------------|--------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------|
| <i>Deforestation</i>                | Biomass                                    | Equation 2.16 and 2.8b of 2006 IPCC Volume 4 GFOI MGD, Chapter 3.1.2 | Tier 2 (above-ground)<br>Tier 1/2 (belowground) |
|                                     | Dead Organic Matter (Dead wood and litter) | Equation 2.23 of 2006 IPCC Volume 4                                  | Tier 2 (Dead wood)<br>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                                          |
| <i>Forest Degradation</i>           | Biomass                                    | GFOI MGD, Chapter 3.1.3                                              | Tier 2 (above-ground)<br>Tier 1/2 (belowground) |
| <i>Enhancement of carbon stocks</i> | Biomass                                    | GFOI MGD, Chapter 3.1.4                                              | Tier 2 (above-ground)<br>Tier 1/2 (belowground) |

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

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

Where:

|            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $ER_{ERP}$ | = | Emission Reductions under the ER Program in year t; tCO <sub>2</sub> e*year <sup>-1</sup> .                                                                                                                                                                                                                                                                                                                                                                                                                             |
| $RL_{RP}$  | = | Gross emissions of the RL from deforestation over the Reference Period; tCO <sub>2</sub> e*year <sup>-1</sup> .<br>This is sourced from Annex 4 of the MR1<br>( <a href="https://docs.google.com/document/d/1ck2jZi-ylyLPndafoYaaHEDXBgP9zJ8F/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true">https://docs.google.com/document/d/1ck2jZi-ylyLPndafoYaaHEDXBgP9zJ8F/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true</a> ) and equations are provided below. |
| $GHG_t$    | = | Monitored gross emissions from deforestation at year t; tCO <sub>2</sub> e*year <sup>-1</sup> ;                                                                                                                                                                                                                                                                                                                                                                                                                         |
| $T$        | = | Number of years during the monitoring period; dimensionless.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

#### MONITORED EMISSIONS (GHGT)

$$GHG_t = \sum_i \Delta C_{B,t,i} + \Delta C_{DOM,t,i} + \Delta C_{SOC,t,i} + L_{fire,t,i} \quad \text{Equation 2}$$

Where:

|                      |   |                                                                                                                           |
|----------------------|---|---------------------------------------------------------------------------------------------------------------------------|
| $\Delta C_{B,t,i}$   | = | Changes in carbon stocks in biomass from REDD+ activity i in year t; tCO <sub>2</sub> e year <sup>-1</sup> .              |
| $\Delta C_{DOM,t,i}$ | = | Changes in carbon stocks in Dead wood and Litter from REDD+ activity i in year t; tCO <sub>2</sub> e year <sup>-1</sup> . |
| $\Delta C_{SOC,t,i}$ | = | Changes in Soil Organic Carbon from REDD+ activity i in year t; tCO <sub>2</sub> e year <sup>-1</sup> .                   |
| $L_{fire,t,i}$       | = | Non-CO <sub>2</sub> emissions from fire in REDD+ activity i in year t; tCO <sub>2</sub> e year <sup>-1</sup> .            |

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

#### Deforestation

##### Changes in carbon stocks in biomass

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

$$\Delta C_{B_t} = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L \quad \text{Equation 2}$$

Where:

|                         |                                                                                                                                                                                        |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\Delta C_{B_t}$        | Annual change of total biomass carbon stocks during the period, in tC per year;                                                                                                        |
| $\Delta C_G$            | 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                                                               |
| $\Delta C_L$            | 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 ( $\Delta C_B$ ) is equal to the initial change in carbon stocks ( $\Delta C_{CONVERSION}$ );

\* <https://www.reddcompass.org/mgd/resources/GFOI-MGD-3.1-en.pdf>

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

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

Where:

$A(j, i)$  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.**

$AGB_{Before,j}$  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            |

$R_j$  The description of this parameter may be found in **Section 3.1. Error! Reference source not found.** 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)<sup>-1</sup>. 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 according to RAZAKAMANARIVO et al. (2013). This is the case for Plantations.

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

$R_i$  The description of this parameter may be found in **Section 3.1. Error! Reference source not found.** 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)<sup>-1</sup>. 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 non-forest.
- 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<sub>2</sub>

#### Changes in carbon stocks in Dead wood and Litter

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

$$\Delta C_{DOM,t} = \frac{(C_n - C_o) \times A(j,i) \times \frac{44}{12}}{T_{on}} \quad \text{Equation 4}$$

Where :

- $A(j, i)$  area undergoing conversion from old to new land-use category, ha. This is the same as parameter  $A(j, i)$  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<sup>-1</sup>.  
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<sup>-1</sup>. 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 CO<sub>2</sub>

#### Changes in Soil Organic Carbon

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

$$\Delta C_{SOC,t} = \frac{\sum_{j,i} [(SOC_{Before,j} - SOC_{After,i}) \times \frac{44}{12} \times A(j,i)]}{D} \quad \text{Equation 5}$$

Where :

$A(j,i)$  land area of the stratum being estimated, ha. This is the same as parameter  $A(j,i)$  also description of this parameter may be found in **Section 3.2**.

$SOC_{Before,j}$  the reference carbon stock, ton C ha<sup>-1</sup> for forests. It has been assumed the same value for the 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<sup>-1</sup> for **non-forest (NF)**.  
 $44/12$  Conversion of C to CO<sub>2</sub>

#### Non-CO<sub>2</sub> emissions from deforestation

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

$$L_{fire,t} = A \times M_B \times C_f \times G_{ef} \times 10^{-3} \quad \text{Equation 6}$$

Where :

$A$  area burnt, ha, 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<sup>-1</sup>. This is equivalent to the biomass prior to conversion  $AGB_j$ . 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<sup>-1</sup> dry matter burnt. This is equal to:

- **6.8** for CH<sub>4</sub> as it is the value for tropical forest according to 2006 IPCC GL Table 2.6
- **0.2** for N<sub>2</sub>O as it is the value for tropical forest according to 2006 IPCC GL Table 2.6

$$L_{fire,t} = A(j,i) \times AGB_{Before,j} \times C_f \times (G_{efCH_4} \times GWP_{CH_4} + G_{efN_2O} \times GWP_{N_2O}) \times 10^{-3} \quad \text{Equation 7}$$

Where :

$GWP_{CH_4}$  Global Warming Potential of CH<sub>4</sub>, = 28

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](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.

$$\Delta C_{B,t} = \sum_{j,i} (AGB_{Before,j} \chi(1 + R_j) - AGB_{After,i} \chi(1 + R_i)) \times CF \times \frac{44}{12} A(j, i) \quad \text{Equation 8}$$

Where :

$A(j, i)$  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**.

$R_j$  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)<sup>-1</sup>. 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, it will be assumed that afforested/reforested lands take 15 years to reach the status of secondary forest. 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:

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

Where :

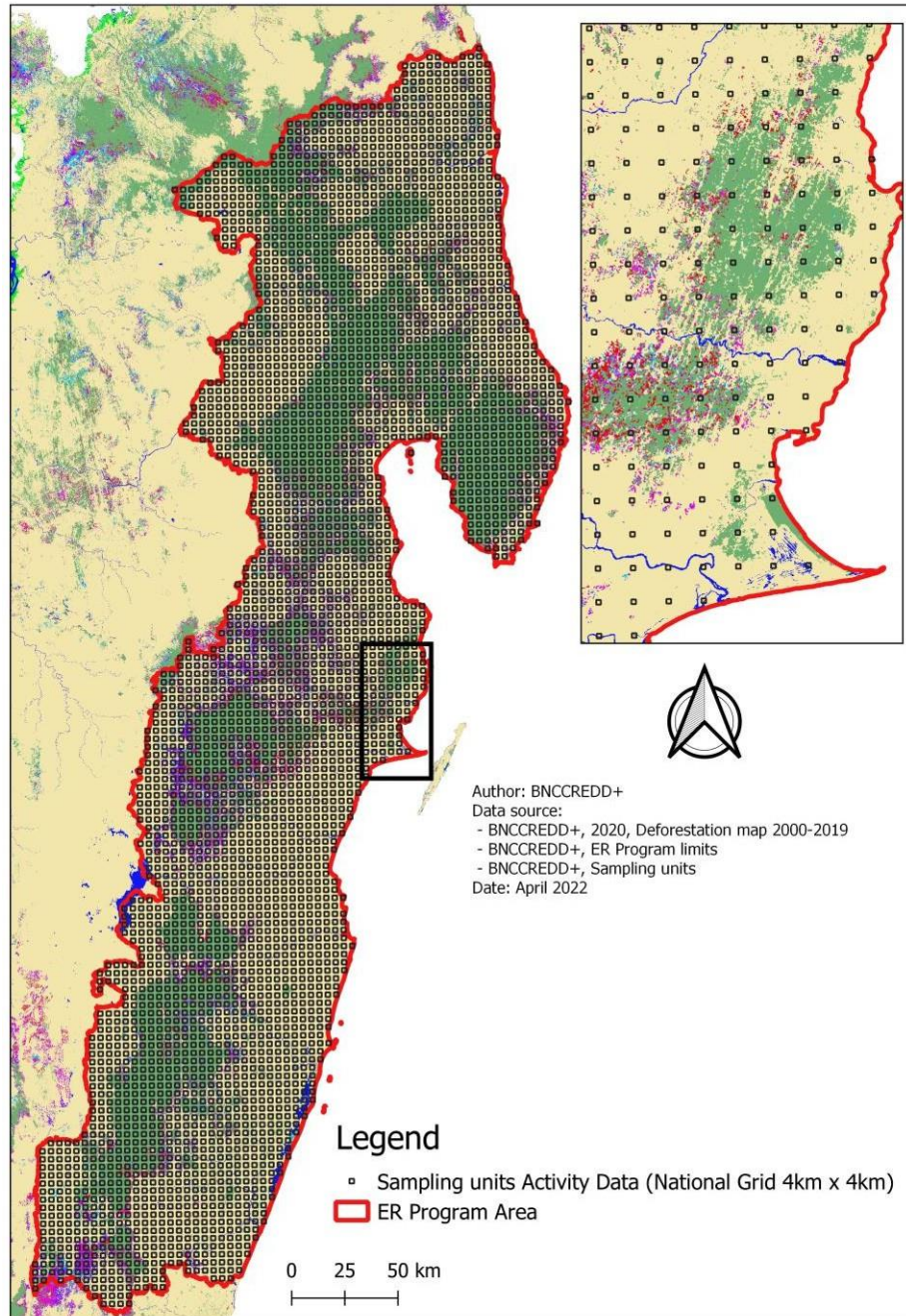
|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\Delta C_B$     | Change of total carbon stocks during the monitoring period, in tC per hectare, per year.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| $A(j, i)$        | 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 <b>Section 3.2</b> . Area of forest converted from non-forest to forest during the monitoring period, in hectare per year. In this case, it would be :                                                                                                                                                                                                                                                                                                                                           |
|                  | <ul style="list-style-type: none"> <li>• <b>Non-forest to Secondary Forest</b></li> <li>• <b>Non-Forest to forestry</b></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| $AGB_{Before,i}$ | 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 <b>non-forest (NF)</b> . The description of this parameter may be found in <b>Section 3.2</b> .                                                                                                                                                                                                                                                                                                                                                                                                                    |
| $AGB_{After,j}$  | Aboveground biomass of forest type j after conversion, in ton of dry matter per ha. The description of this parameter may be found in <b>Section 3.1</b> . In this case, it would be the aboveground biomass of :                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                  | <ul style="list-style-type: none"> <li>• <b>Secondary Forest (SF);</b></li> <li>• <b>Agroforestry (AF);</b></li> <li>• <b>Plantations (PL);</b></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| $R_{\square}$    | 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) <sup>-1</sup> . This is equal to: <ul style="list-style-type: none"> <li>• <b>0.2</b> is the default for tropical moist deciduous forest when aboveground biomass is &lt;125 t.d.m./ha according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for <u>Secondary Forest, Agroforestry and non-forest</u>.</li> <li>• <b>3.24</b> is the root shoot ratio of Eucalyptus plantations according to RAZAKAMANARIVO et al. (2013). This is the case for <u>Plantations</u>.</li> </ul> |
| Years growth     | Number of years to transit from Non-forest to forest. The value used is: <ul style="list-style-type: none"> <li>• <b>15</b> 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 5 years in average.</li> </ul>                                                                                                                                                                                                                                                                                                                                           |
| $CF$             | Carbon fraction of dry matter in tC per ton dry matter. The value used is: <ul style="list-style-type: none"> <li>• <b>0.47</b> is the default for tropical forest as per IPCC AFOLU guidelines 2006, table 4.3.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 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 :

|                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Parameters :</b>                                                                                                                                            | $A(j, i), A(i, j)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Description :</b>                                                                                                                                           | <ul style="list-style-type: none"> <li>• Annual conversion from forest type <math>j</math> (primary forest, modified natural forest), to non-Forest Land uses <math>i</math> (Non-Forest) in period 2006-2015</li> <li>• Annual conversion from forest type <math>j</math> (primary forest), to Forest type <math>i</math> (modified natural forest or plantations) in period 2006-2015</li> <li>• Annual conversion from non-Forest Land use <math>i</math> to forest type <math>j</math> (planted forest or modified natural forest) in period 2006-2015</li> </ul>                                                                       |
| <b>Data unit :</b>                                                                                                                                             | ha/year                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):</b> | <p>As indicated previously, design-based inference has been used to estimate the activity data.</p> <p>Sampling design<br/>Estimator:<br/>Simple random estimator of a proportion</p> <p>Stratification:<br/>No stratification.</p> <p>Calculation of the sample size:<br/>No calculation since it was based on the data from the national grid.</p> <p>Drawing of samples<br/>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.</p> |



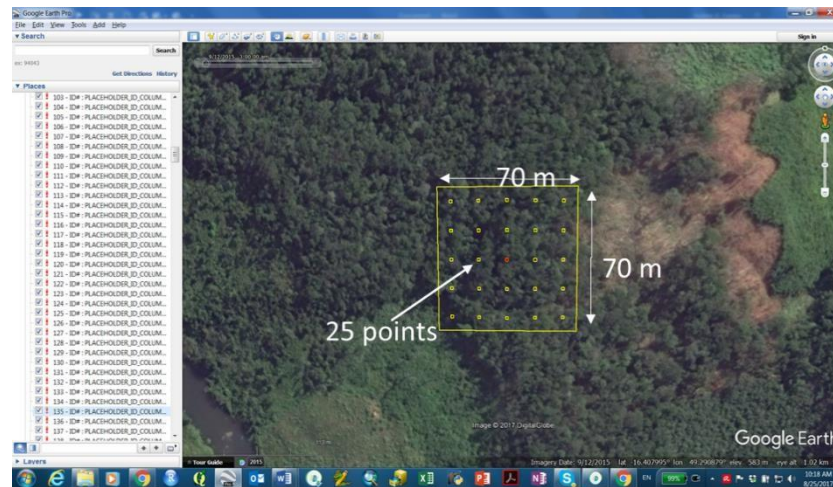
Location of sampling units

### 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:

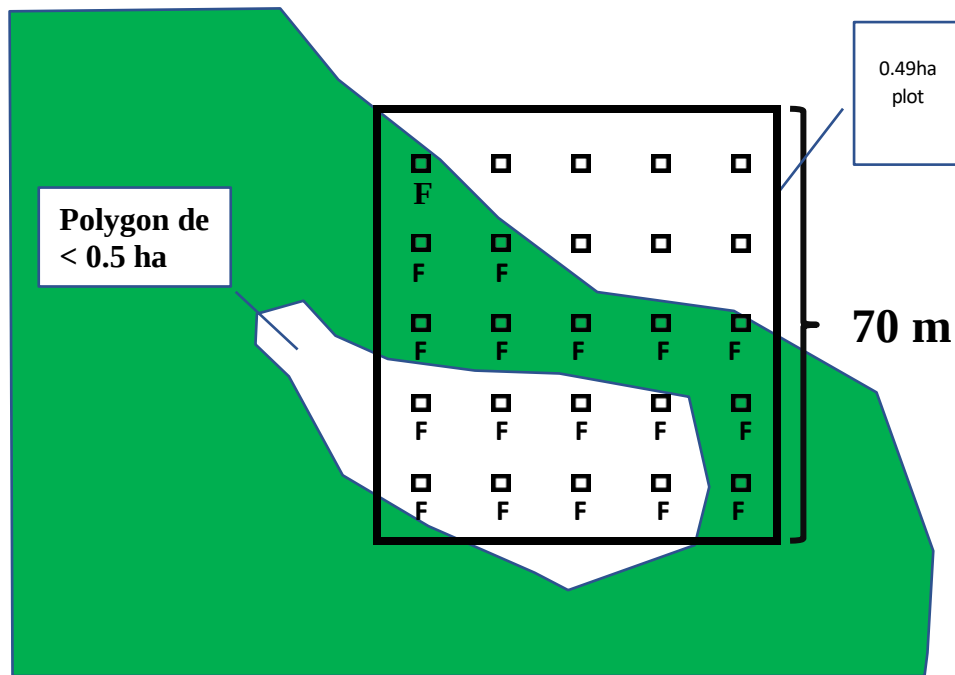
The reference data in this case will be collected through visual interpretation of all satellite imagery available to the country. This includes:

- Planet basemap : from 2016 to 2021, with 4.7m high resolution imagery available through the NICFI grants to tropical countries. Planet data has more recent imagery compared to other high resolution satellite images.
- 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.

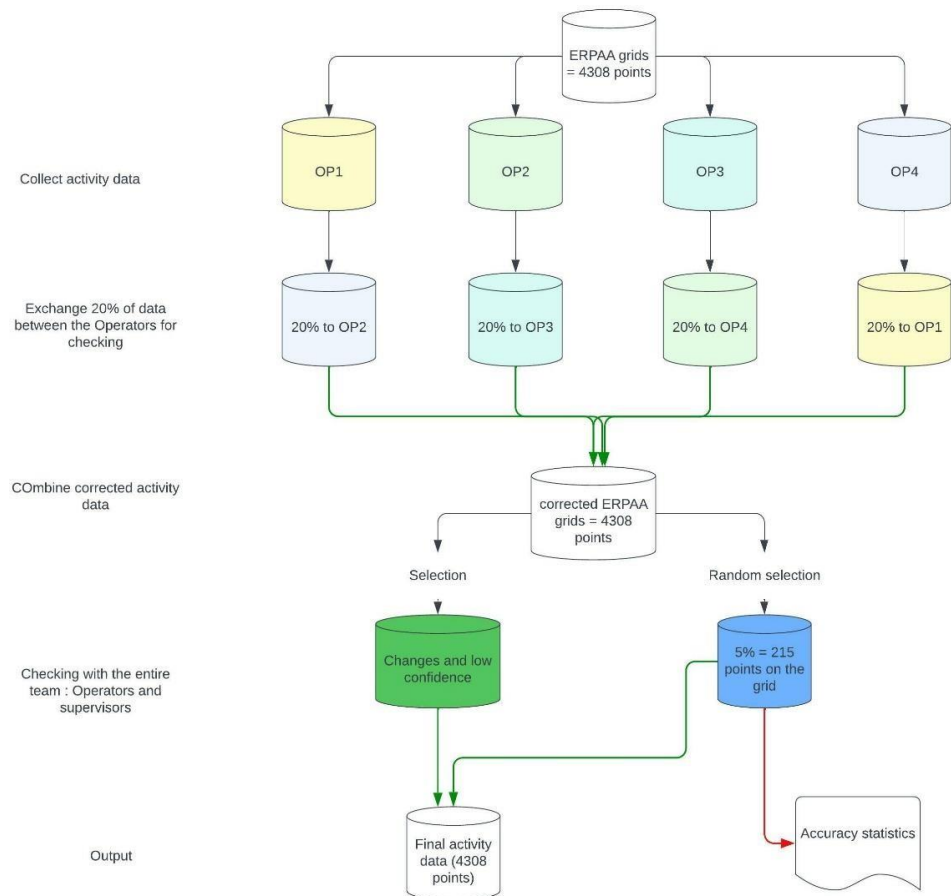


#### Example of interpretation of sampling unit

- 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](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)<br>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           |

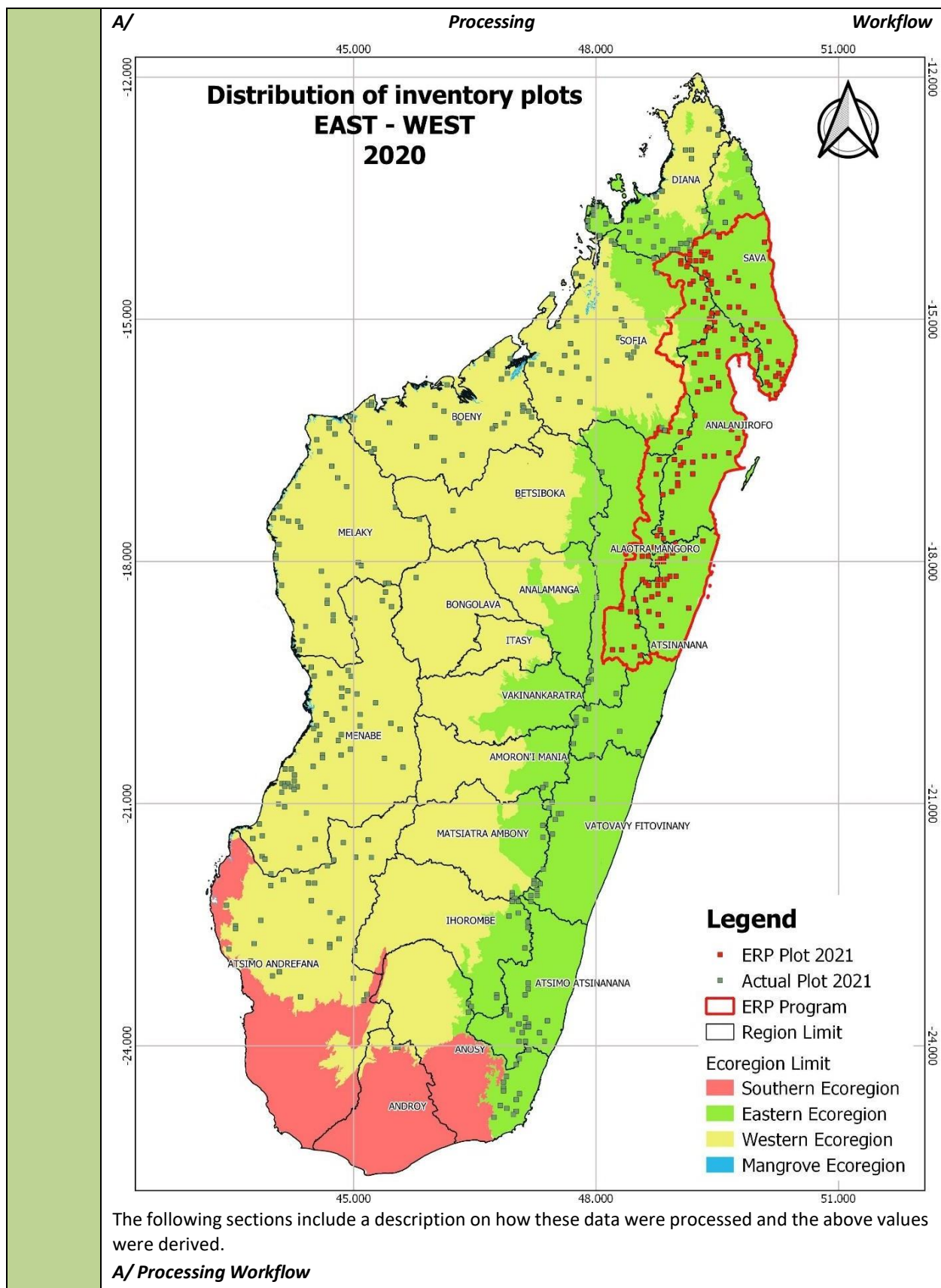
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>OO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Stable bare soil  | 0.00    | 0.00               |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------|--------------------|----------|----------------|---------------|--------------------|---------------|-----------------------|----------|------------------|-----------------------|--------------|---------|------------------|---------|-------------|------------------------|----------|--------------------|-------------|--------|---|-------------|------------------|-------|-------|--------------|--------|---|-------------|--------|---|-------------|------------------------|-------|---------|--------------------|--------|---|-------------------|--------|---|--------------------|--------|---|-------------------|--------|---|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>SS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Stable Artificial | 0.00    | 0.00               |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>WW</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 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 6,980,308 ha.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                   |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Estimate of proportions per class                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                   |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <table><tr><th>Activity</th><th>Type</th><th></th><th>Area estimate (ha)</th></tr><tr><td rowspan="5">Deforestation</td><td>Dense humid forest</td><td>0.004</td><td>27,502</td></tr><tr><td>Degraded humid forest</td><td>0.032</td><td>225,185</td></tr><tr><td>Secondary forest</td><td>0.00023</td><td>1,605</td></tr><tr><td>Agroforestry</td><td>0.00023</td><td>1,605</td></tr><tr><td>Plantations</td><td>0.0000</td><td>0</td></tr><tr><td rowspan="3">Enhancement</td><td>Secondary forest</td><td>0.001</td><td>8,097</td></tr><tr><td>Agroforestry</td><td>0.0000</td><td>0</td></tr><tr><td>Plantations</td><td>0.0000</td><td>0</td></tr><tr><td rowspan="5">Degradation</td><td>PF to Disturbed forest</td><td>0.017</td><td>118,246</td></tr><tr><td>PF to Agroforestry</td><td>0.0000</td><td>0</td></tr><tr><td>PF to Plantations</td><td>0.0000</td><td>0</td></tr><tr><td>DF to Agroforestry</td><td>0.0000</td><td>0</td></tr><tr><td>DF to Plantations</td><td>0.0000</td><td>0</td></tr></table> |                   |         |                    | Activity | Type           |               | Area estimate (ha) | Deforestation | Dense humid forest    | 0.004    | 27,502           | Degraded humid forest | 0.032        | 225,185 | Secondary forest | 0.00023 | 1,605       | Agroforestry           | 0.00023  | 1,605              | Plantations | 0.0000 | 0 | Enhancement | Secondary forest | 0.001 | 8,097 | Agroforestry | 0.0000 | 0 | Plantations | 0.0000 | 0 | Degradation | PF to Disturbed forest | 0.017 | 118,246 | PF to Agroforestry | 0.0000 | 0 | PF to Plantations | 0.0000 | 0 | DF to Agroforestry | 0.0000 | 0 | DF to Plantations | 0.0000 | 0 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Activity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Type              |         | Area estimate (ha) |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
| Deforestation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Dense humid forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.004             | 27,502  |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Degraded humid forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0.032             | 225,185 |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Secondary forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0.00023           | 1,605   |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Agroforestry                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0.00023           | 1,605   |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Plantations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0.0000            | 0       |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
| Enhancement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Secondary forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0.001             | 8,097   |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Agroforestry                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0.0000            | 0       |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Plantations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0.0000            | 0       |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
| Degradation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | PF to Disturbed forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0.017             | 118,246 |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                   |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
| <table><tr><th>Activity</th><th>Type</th><th>Area (ha/year)</th></tr><tr><td rowspan="5">Deforestation</td><td>Dense humid forest</td><td>2750.24</td></tr><tr><td>Degraded humid forest</td><td>22518.47</td></tr><tr><td>Secondary forest</td><td>160.55</td></tr><tr><td>Agroforestry</td><td>160.55</td></tr><tr><td>Plantations</td><td>0</td></tr><tr><td rowspan="2">Degradation</td><td>PF to Disturbed forest</td><td>11824.64</td></tr><tr><td>PF to Agroforestry</td><td>0</td></tr></table> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                   |         | Activity           | Type     | Area (ha/year) | Deforestation | Dense humid forest | 2750.24       | Degraded humid forest | 22518.47 | Secondary forest | 160.55                | Agroforestry | 160.55  | Plantations      | 0       | Degradation | PF to Disturbed forest | 11824.64 | PF to Agroforestry | 0           |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
| Activity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Area (ha/year)    |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
| Deforestation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Dense humid forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 2750.24           |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Degraded humid forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 22518.47          |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Secondary forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 160.55            |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Agroforestry                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 160.55            |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Plantations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0                 |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
| Degradation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | PF to Disturbed forest                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 11824.64          |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | PF to Agroforestry                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0                 |         |                    |          |                |               |                    |               |                       |          |                  |                       |              |         |                  |         |             |                        |          |                    |             |        |   |             |                  |       |       |              |        |   |             |        |   |             |                        |       |         |                    |        |   |                   |        |   |                    |        |   |                   |        |   |

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|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | PF to Plantations      | 0                     |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | DF to Agroforestry     | 0                     |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | DF to Plantations      | 0                     |
|                                   | <i>Enhancement</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Secondary forest       | 809.72                |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Agroforestry           | 0                     |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Plantations            | 0                     |
|                                   | <p>More information is provided in the spreadsheet (cf file in this link)<br/> <a href="https://docs.google.com/spreadsheets/d/1pYtVTN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true">“https://docs.google.com/spreadsheets/d/1pYtVTN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true”</a></p> <p>”</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                       |
| <b>Value applied :</b>            | <b>Activity</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Type</b>            | <b>Area (ha/year)</b> |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                        |                       |
|                                   | Deforestation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Dense humid forest     | 2750.24               |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Degraded humid forest  | 22518.47              |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Secondary forest       | 160.55                |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Agroforestry           | 160.55                |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Plantations            | 0                     |
|                                   | Degradation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | PF to Disturbed forest | 11824.64              |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | PF to Agroforestry     | 0                     |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | PF to Plantations      | 0                     |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | DF to Agroforestry     | 0                     |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | DF to Plantations      | 0                     |
|                                   | Enhancement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Secondary forest       | 809.72                |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Agroforestry           | 0                     |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Plantations            | 0                     |
| <b>QA/QC procedures applied :</b> | <ul style="list-style-type: none"> <li>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:<br/> <a href="https://drive.google.com/file/d/1Qf4PIgjuv03clSYtpbhC9_HboXIRP1go/view?usp=sharing">https://drive.google.com/file/d/1Qf4PIgjuv03clSYtpbhC9_HboXIRP1go/view?usp=sharing</a></li> <li>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.</li> <li>Expert interpreters were used, sufficiently trained, with a specific SOP for interpretation.</li> <li>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</li> </ul> |                        |                       |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                        |                       |
|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                        |                       |
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|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                        |                                    |                                                  |
|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------------------------------|--------------------------------------------------|
|                                             | <p>interpretation. All sampling units labelled as low-confidence are re-assessed by an expert interpreter.</p> <ul style="list-style-type: none"> <li>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 (<a href="https://drive.google.com/file/d/1Qf4PIgJvx03clSYtpbhC9_HboXIRP1go/view?usp=sharing">https://drive.google.com/file/d/1Qf4PIgJvx03clSYtpbhC9_HboXIRP1go/view?usp=sharing</a>).</li> <li>During data analysis: The Laboratory and Methodology Manager, in coordination with the analysts, check that the calculations comply with SOP number 4 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...) (<a href="https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing">https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing</a>).</li> </ul> |                        |                                    |                                                  |
| Uncertainty associated with this parameter: | <b>Activity</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Type</b>            | <b>Standard error (proportion)</b> | <b>90% confidence – Relative margin of error</b> |
|                                             | <i>Deforestation</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Dense humid forest     | 0.001                              | 40%                                              |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Degraded humid forest  | 0.003                              | 14%                                              |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Secondary forest       | 0.00023                            | 165%                                             |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Agroforestry           | 0.00023                            | 165%                                             |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Plantations            | -                                  |                                                  |
|                                             | <i>Enhancement</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Secondary forest       | 0.001                              | 72%                                              |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Agroforestry           | -                                  |                                                  |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Plantations            | -                                  |                                                  |
|                                             | <i>Degradation</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | PF to Disturbed forest | 0.002                              | 19%                                              |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | PF to Agroforestry     |                                    |                                                  |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | PF to Plantations      | -                                  |                                                  |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | DF to Agroforestry     | -                                  |                                                  |
|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | DF to Plantations      | -                                  |                                                  |
| Any comment:                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                        |                                    |                                                  |

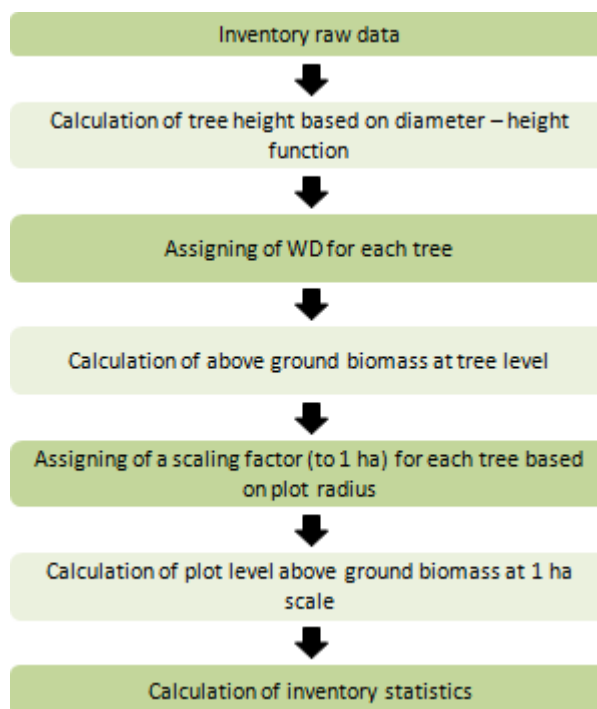
|                     |                                                                                                                                                                                                                                                                                                                                                  |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Parameter:</b>   | $AGB_{Before,j} - AGB_{After,j}$ (For Forest)                                                                                                                                                                                                                                                                                                    |
| <b>Description:</b> | 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): | <p>Data came from three main sources:</p> <ul style="list-style-type: none"><li>• 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.</li><li>• 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.</li><li>• 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.</li></ul> <p>Estimates of AGB according to inventory DRGPF, 2020</p> <table><tr><th>Stratum</th><th colspan="2">AGB (tdm/ha)</th></tr><tr><td></td><td>202.63</td><td>7%</td></tr><tr><td></td><td>186.00</td><td>11%</td></tr><tr><td></td><td>91.11</td><td>30%</td></tr></table> <p><b>Distribution of forest inventory plots</b></p> <p>The following sections include a description on how these data were processed and the above values were derived.</p> | Stratum | AGB (tdm/ha) |  |  | 202.63 | 7% |  | 186.00 | 11% |  | 91.11 | 30% |
| Stratum                                                                                                                                                 | AGB (tdm/ha)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |         |              |  |  |        |    |  |        |     |  |       |     |
|                                                                                                                                                         | 202.63                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 7%      |              |  |  |        |    |  |        |     |  |       |     |
|                                                                                                                                                         | 186.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 11%     |              |  |  |        |    |  |        |     |  |       |     |
|                                                                                                                                                         | 91.11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 30%     |              |  |  |        |    |  |        |     |  |       |     |



Inventory data was processed as follows.

Inventory data processing workflow



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

- (Woody) trees of dbh  $\geq 5$  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  | $\ln(H) = -0.07511 \cdot \ln(D)^2 + 0.988 \cdot \ln(D) + 0.267$                              | 1,270           | N/A         |
| « Savoka vieux » or « Agroforestry » strata of the 2016 inventory | 2  | $\ln(H) = -0.0709 \cdot \ln(D)^2 + 0.9257 \cdot \ln(D) + 0.371$                              | 1,365           | N/A         |
| « Mix Ravenala » strata of the 2016 inventory                     | 3  | $\ln(H) = -0.106 \cdot \ln(D)^2 + 1.1305 \cdot \ln(D) + 0.0097$                              | 499             | N/A         |
| Palm: <i>Dypsis sp.</i>                                           | 4  | $H_{stip} = 0.3772 \cdot H + 1.7639$                                                         | 25              | N/A         |
| Palm: <i>Ravenala madagascariensis</i>                            | 5  | $\ln(H) = -0.0699 \cdot \ln(DHC)^2 + 0.9956 \cdot \ln(DHC) - 0.8902$                         | 1,010           | N/A         |
|                                                                   | 6  | $H = 0.9391 \cdot H_{stip} + 5.7537$                                                         | 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)                                  |    | $H = 1.389026 \times \exp(0.980517 \times \ln(D)) \cdot \exp(-0.07032031 \times (\ln(D))^2)$ | 2519            | 16%         |
| Humid forest (Vieilledent et al 2012)                             |    | $\ln(H) = 1.010 + 0.547 \cdot \ln(D) + \text{Error}$                                         | 250             | +4.7 meter  |

Where:

H: total height, in m

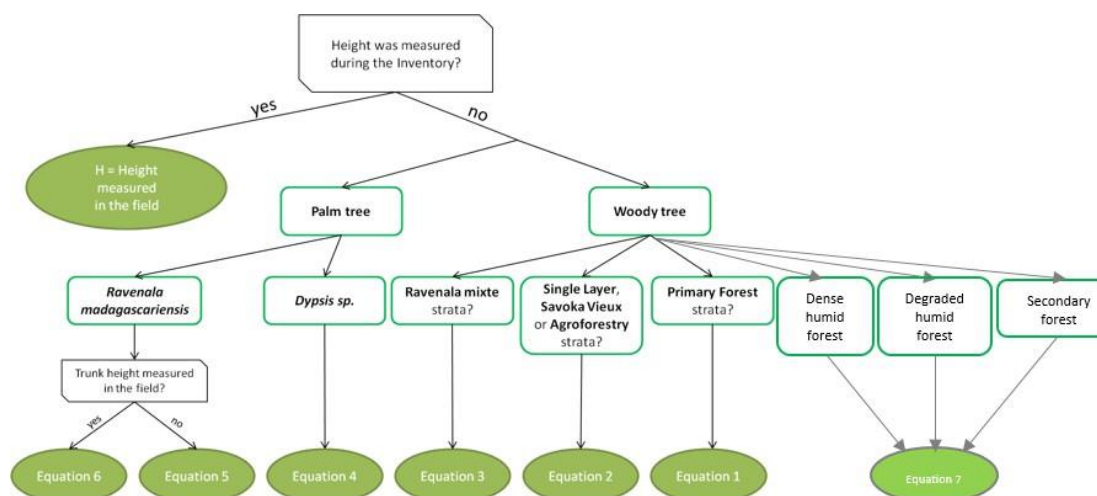
D: diameter at breast height, in cm

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

H<sub>stip</sub>: 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.

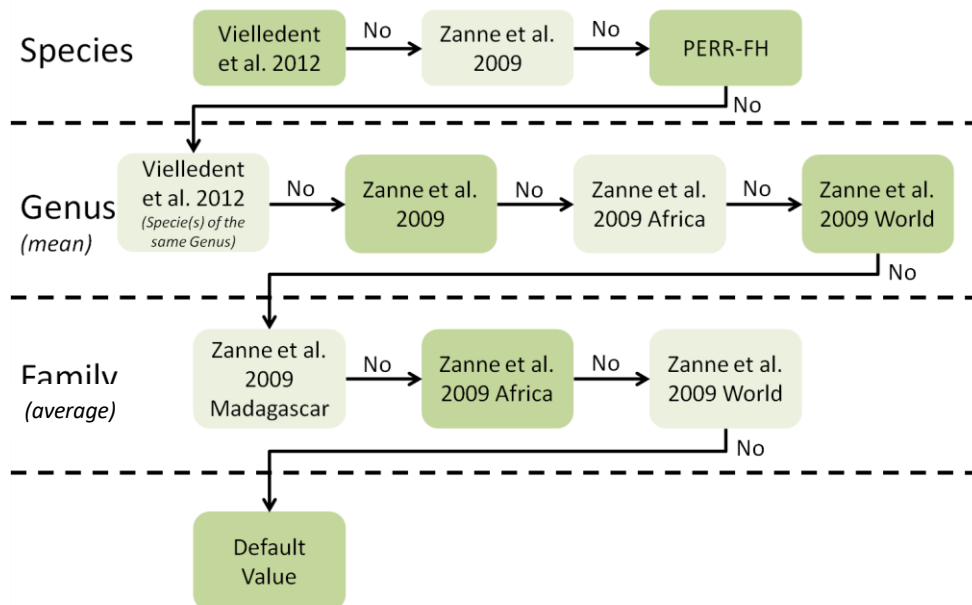


Decision tree to calculate height

### 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 Vieilledent et al (2012), Zanne et al (2009), Zanne 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 Vieilledent 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)                                                                                    | $\ln(AGB_{est}) = 1.103 + 1.994 \cdot \ln(D) + 0.317 \cdot \ln(H_{tot}) + 1.303 \cdot \ln(\rho)$ | Vieilledent et al. (2012)  |
|                   | Primary forests (PERR-FH 2014 inventory), modified forests ('Old Savoka' or 'Agroforestry' strata of the 2016 Inventory) | $\ln(AGB_{est}) = 1.948 + 1.969 \cdot \ln(D) + 0.66 \cdot \ln(H_{tot}) + 0.828 \cdot \ln(\rho)$  | Vieilledent et al. (2012)  |
|                   | (woody) trees of modified forests (« Ravenala mixte » strata of the inventory)                                           | $\ln(AGB_{est}) = -1.56 + 1.912 \cdot \ln(D) + 0.471 \cdot \ln(H_{tot}) + 0.732 \cdot \ln(\rho)$ | Randrianasolo et al., 2017 |
|                   | <i>Ravenala madagascariensis</i>                                                                                         | $\ln(AGB_{est}) = -5.08 + 5.654 \cdot \ln(H_{tot}) - 0.772 \cdot \ln(H_{tot})^2$                 | Randrianasolo et al., 2017 |
| Palms             |                                                                                                                          |                                                                                                  |                            |

*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

$\rho$ : 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]<br>Ecoregion |               |
|----------------------|---------|-------|-------|-----------------------|---------------|
|                      |         |       |       | Est                   | Ouest         |
| <b>Small trees</b>   | 10      | 100   | 100   | 5 < DBH ≤ 15          | 5 < DBH ≤ 10  |
| <b>Medium trees</b>  | 20      | 400   | 25    | 15 < DBH ≤ 30         | 10 < DBH ≤ 20 |
| <b>Large trees</b>   | 50      | 2,500 | 4     | ≥ 30                  | ≥ 20          |
| <b>Regenerations</b> | (1*1)*4 | 4     | 2,500 | < 5                   | < 5           |

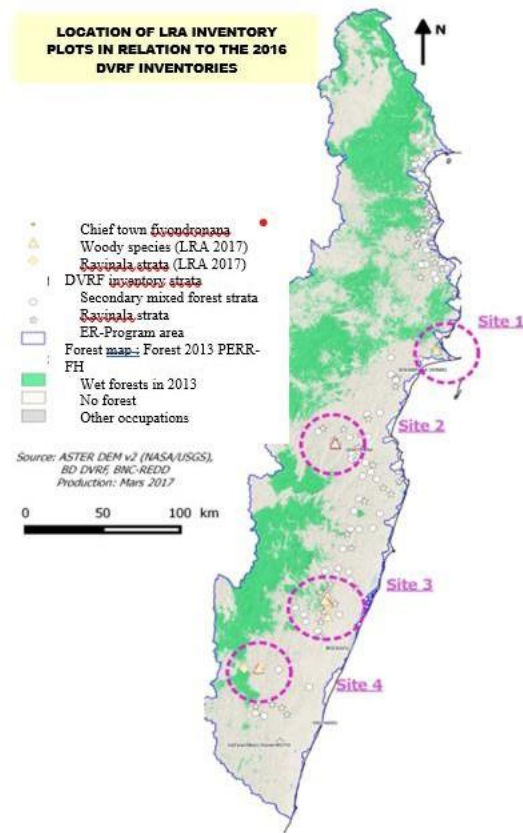
DBH (cm), total height (m), dead tree quality were recorded.

#### ***F/ Inference***

|                                                                                                                                                                                                                                                                                                                             | <b>* Arithmetic mean</b>                                                                                                                                                                                                                                                                                                                                                                        |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------|--------------------|--------|-----------------------|--------------------|------------------|-------|-----------------------|--------|------------|------------------|-------|----|
|                                                                                                                                                                                                                                                                                                                             | 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.                                                                                                                                                                                                        |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
|                                                                                                                                                                                                                                                                                                                             | $\bar{y} = \frac{\sum_{i=1}^n y_i}{n} \quad (13)$                                                                                                                                                                                                                                                                                                                                               |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
|                                                                                                                                                                                                                                                                                                                             | Where $y_i$ is the parameter value for the $i^{\text{th}}$ 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                                                                                                                                                                                                                                                                                                                                               |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
|                                                                                                                                                                                                                                                                                                                             | <table><tr><th>Forest type</th><th></th><th></th></tr><tr><td>Dense humid forest</td><td>202.63</td><td>155</td></tr><tr><td>Degraded humid forest</td><td>186.00</td><td>85</td></tr><tr><td>Secondary forest</td><td>91.11</td><td>21</td></tr></table>                                                                                                                                       |             |                   | Forest type        |        |                       | Dense humid forest | 202.63           | 155   | Degraded humid forest | 186.00 | 85         | Secondary forest | 91.11 | 21 |
|                                                                                                                                                                                                                                                                                                                             | Forest type                                                                                                                                                                                                                                                                                                                                                                                     |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
|                                                                                                                                                                                                                                                                                                                             | Dense humid forest                                                                                                                                                                                                                                                                                                                                                                              | 202.63      | 155               |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
| Degraded humid forest                                                                                                                                                                                                                                                                                                       | 186.00                                                                                                                                                                                                                                                                                                                                                                                          | 85          |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
| Secondary forest                                                                                                                                                                                                                                                                                                            | 91.11                                                                                                                                                                                                                                                                                                                                                                                           | 21          |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
| More information is provided in the spreadsheet “                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                 |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
| MADA_Biomasse_aerienne_et_Morte_20220410_v01                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                 |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
| ” which may be found in the link                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                 |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
| <a href="https://docs.google.com/spreadsheets/d/1vSxK577AX1WNDap0K8CbYtCGgoDT6OIV/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true">https://docs.google.com/spreadsheets/d/1vSxK577AX1WNDap0K8CbYtCGgoDT6OIV/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true</a> |                                                                                                                                                                                                                                                                                                                                                                                                 |             |                   |                    |        |                       |                    |                  |       |                       |        |            |                  |       |    |
| Value applied:                                                                                                                                                                                                                                                                                                              | <table><tr><th>Forest type</th><th>Estimate (tdm/ha)</th></tr><tr><td>Dense Humid forest</td><td>202.63</td></tr><tr><td>Degraded humid forest</td><td>186.00</td></tr><tr><td>Secondary Forest</td><td>91.11</td></tr><tr><td>Agroforestry</td><td>87.87</td></tr><tr><td>Plantation</td><td>29.55</td></tr></table>                                                                           | 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            |       |    |
| 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 parameter: | <b>Class</b>                                                                                                                      | <b>BA (tdm/ha)</b> | <b>Stdev</b> | <b>Number of samples</b> | <b>SE</b> | <b>Relative margin of error at 90%</b> |  |
|                                             | Dense Humid forest                                                                                                                | 202.63             | 99.59        | 155                      | 8.00      | 7%                                     |  |
|                                             | Degraded humid forest                                                                                                             | 186.00             | 111.90       | 85                       | 12.14     | 11%                                    |  |
|                                             | 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:                                |                                                                                                                                   |                    |              |                          |           |                                        |  |

|                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Parameter:</b>                                                                                                                                               | $AGB_{After,i} - AGB_{Before,i}$ (non-forest)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Description :</b>                                                                                                                                            | Aboveground biomass of non-forest type j before conversion, in tonne of dry matter per ha<br>Aboveground biomass of non-forest type i after conversion, in tonnes dry matter per ha;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Data unit:</b>                                                                                                                                               | tdm/ha                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international) :</b> | <p>This are sourced from a destructive sampling of Savoka Jeune secondary formations conducted as part of the Laboratoire de Recherches Appliquées in 2016-2017. These formations are the precursors of Savoka vieux, Ravenala mix and agroforestry formations.</p> <p><b>A/ Sampling design</b></p> <p>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:</p> <ul style="list-style-type: none"> <li>• Site 1 (Axe Soanierana Ivongo): centre of the ER program and below 200 m of altitude;</li> <li>• Site 2 (Axe Vavatenina): centre of the ER program and at least 400 m of altitude; ;</li> <li>• Site 3 (Axe Brickaville): south of the. ER program and below 400 m of altitude;</li> <li>• Site 4 (Axe Andasibe): south of the ER program and above 400 m of altitude.</li> </ul> |



Location of plots for estimation of biomass in non-forest

In each of the sites several 1 m<sup>2</sup> 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

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

### **B/ Measurement**

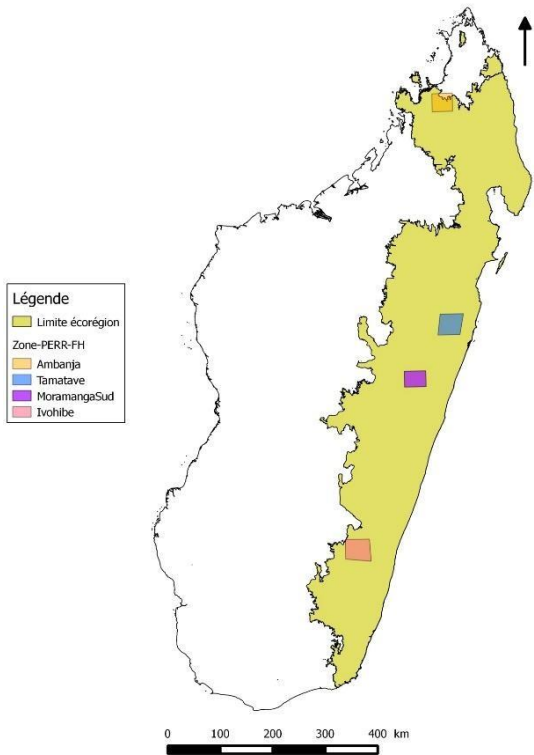
Within these plots, a destructive measurement of herbaceous vegetation and woody vegetation was made. The samples were then taken to laboratory and the samples were dried at a

|                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                    | <p>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.</p>  <p>Picture of bags with destructive samples</p> <p>The anhydrous mass of the shrubs and grasses has been measured with a balance with 0.01 g accuracy.</p> <p><b>C/ Statistical analysis</b></p> <p>Different statistical parameters was evaluated:</p> <p>The average estimate of Aboveground Biomass is estimated through the random estimator of the mean (<math>\hat{\mu}_{\square}</math>):</p> $\hat{\mu}_{\square} = \frac{1}{n_{\square}} \sum_{k=1}^{n_{\square}} y_k$ <p>Where:</p> <ul style="list-style-type: none"> <li>• <math>y_k</math> is the k sample estimate given by the biomass estimated per plot as described above. This is the biomass per sampling unit estimated above.</li> <li>• <math>n</math> is the number of samples</li> <li>• For the all four sites, the biomass factor for Savoka jeunes is of 11.96 ±6.5 t/ha.</li> </ul> |
| <b>Value applied:</b>                              | 11.96                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>QA/QC procedures applied:</b>                   | Inventory quality control: technical supervision by DRGPF and BNCCREDD+ supervisors and strategic supervision by MEDD staff, verification of inventory sheets and databases.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Uncertainty associated with this parameter:</b> | <p>The main uncertainty is the sampling uncertainty and the representativeness of the data. See Chapter 12.</p> <p>The sampling error is estimated through the following formula.</p> $Standard\ error(\hat{\mu}) = \frac{1}{\sqrt{n} \times (n-1)} \times \sum_{k=1}^{n_{\square}} (y_k - \hat{\mu})^2$ <p>Where:</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

|                 | <ul style="list-style-type: none"><li>• <math>y_k</math> is the k sample estimate given by the biomass estimated per plot as described above. This is the biomass per sampling unit estimated above;</li><li>• <math>\hat{\mu}</math> the random estimator of the mean;</li><li>• <math>n</math> is the number of samples.</li></ul> |       |                         |       |                                       |    |                                       |            |       |  |     |      |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------------|-------|---------------------------------------|----|---------------------------------------|------------|-------|--|-----|------|
|                 | <p>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.</p>                                                                                                  |       |                         |       |                                       |    |                                       |            |       |  |     |      |
|                 | <p>Estimates of AGB in non-forest</p> <table><tr><th>Class</th><th>AGB<br/>(tdm/ha)</th><th>Stdev</th><th>Number<br/>of<br/>samples</th><th>SE</th><th>Relative<br/>margin of<br/>error at 90%</th></tr><tr><td>Non Forest</td><td>11.96</td><td></td><td>120</td><td>3.28</td><td>46%</td></tr></table>                             | Class | AGB<br>(tdm/ha)         | Stdev | Number<br>of<br>samples               | SE | Relative<br>margin of<br>error at 90% | Non Forest | 11.96 |  | 120 | 3.28 |
| Class           | AGB<br>(tdm/ha)                                                                                                                                                                                                                                                                                                                      | Stdev | Number<br>of<br>samples | SE    | Relative<br>margin of<br>error at 90% |    |                                       |            |       |  |     |      |
| Non Forest      | 11.96                                                                                                                                                                                                                                                                                                                                |       | 120                     | 3.28  | 46%                                   |    |                                       |            |       |  |     |      |
| Any<br>comment: |                                                                                                                                                                                                                                                                                                                                      |       |                         |       |                                       |    |                                       |            |       |  |     |      |

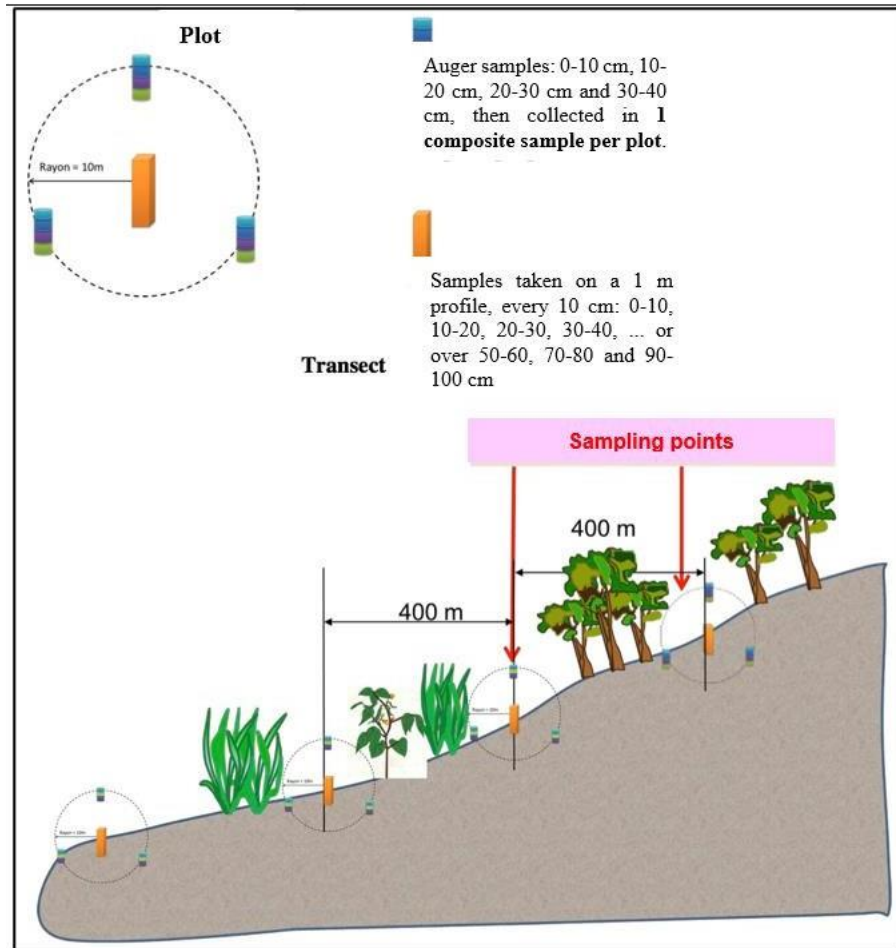
| Parameter:                                                                                                                                              | $C_0$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |             |       |                    |             |                       |      |                       |      |                  |      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------|--------------------|-------------|-----------------------|------|-----------------------|------|------------------|------|
| Description :                                                                                                                                           | Dead wood/litter stock, under the old land-use category, 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): | <p>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:</p> <p>Estimates of dead wood per forest type</p> <table><tr><th>Forest type</th><th>DW (tdm/ha)</th></tr><tr><td>Dense humid forest</td><td>0.08</td></tr><tr><td>Degraded humid forest</td><td>0.09</td></tr><tr><td>Secondary forest</td><td>0.06</td></tr></table> <p>These values were then multiplied by 0.47 in order to provide the carbon stocks.</p> |             |       | Forest type        | DW (tdm/ha) | Dense humid forest    | 0.08 | Degraded humid forest | 0.09 | Secondary forest | 0.06 |
| Forest type                                                                                                                                             | DW (tdm/ha)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |       |                    |             |                       |      |                       |      |                  |      |
| Dense humid forest                                                                                                                                      | 0.08                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |       |                    |             |                       |      |                       |      |                  |      |
| Degraded humid forest                                                                                                                                   | 0.09                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |       |                    |             |                       |      |                       |      |                  |      |
| Secondary forest                                                                                                                                        | 0.06                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |       |                    |             |                       |      |                       |      |                  |      |
| Value applied:                                                                                                                                          | <table><tr><th>Forest type</th><th>Value</th></tr><tr><td>Dense humid forest</td><td>0.08</td></tr><tr><td>Degraded humid forest</td><td>0.09</td></tr><tr><td>Secondary forest</td><td>0.06</td></tr></table>                                                                                                                                                                                                                                                                                                                                     | Forest type | Value | Dense humid forest | 0.08        | Degraded humid forest | 0.09 | Secondary forest      | 0.06 |                  |      |
| Forest type                                                                                                                                             | Value                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |             |       |                    |             |                       |      |                       |      |                  |      |
| Dense humid forest                                                                                                                                      | 0.08                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |       |                    |             |                       |      |                       |      |                  |      |
| Degraded humid forest                                                                                                                                   | 0.09                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |       |                    |             |                       |      |                       |      |                  |      |
| Secondary forest                                                                                                                                        | 0.06                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |       |                    |             |                       |      |                       |      |                  |      |
| QA/QC procedures applied:                                                                                                                               | Inventory quality control: technical supervision by DRGPF and BNCCREDD+ supervisors and strategic supervision by MEDD staff, verification of inventory sheets and databases.                                                                                                                                                                                                                                                                                                                                                                       |             |       |                    |             |                       |      |                       |      |                  |      |

| Uncertainty associated with this parameter: | <i>Class</i>          | DW (tdm/ha) | SE   | Relative margin of error at 90% |
|---------------------------------------------|-----------------------|-------------|------|---------------------------------|
|                                             | Dense humid forest    | 0.08        | 0.01 | 19%                             |
|                                             | Degraded humid forest | 0.09        | 0.01 | 21%                             |
|                                             | Secondary forest      | 0.06        | 0.02 | 67%                             |
| Any comment:                                |                       |             |      |                                 |

|                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Parameter:                                                                                                                                              | $SOC_{Before,j}$ $SOC_{After,i}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Description :                                                                                                                                           | <p>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.</p> <p><math>SOC_{Before}</math> corresponds to SOC of the forest and <math>SOC_{After}</math> corresponds to SOC of non forest</p>                                                                                                                                                                                                                                                                                                                                                                                             |
| 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): | <p>The data of soil estimates are based on a specific inventory conducted in the Eastern Humid Ecoregion as part of the PERR-FH (<a href="https://redd.unfccc.int/files/20180528_frel_mada_modified.pdf">https://redd.unfccc.int/files/20180528_frel_mada_modified.pdf</a>)</p> <p><b>A/ Sampling plan</b></p> <p>The inventory consistent in sampling in four different regions within the ecoregion, where 5 different chrono sequences were established.</p>  <p><b>Légende</b></p> <ul style="list-style-type: none"> <li>Limite écorégion</li> <li>Zone-PERR-FH</li> <li>Ambanja</li> <li>Tamatave</li> <li>MoramangaSud</li> <li>Ivohibe</li> </ul> |

## 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

| <b>Class</b>         | <b>Forest</b> | <b>Non-Forest</b> | <b>Total</b> |
|----------------------|---------------|-------------------|--------------|
| <i>Ambanja</i>       | 26            | 24                | 50           |
| <i>Tamatave Est</i>  | 22            | 28                | 50           |
| <i>Moramanga Sud</i> | 11            | 39                | 50           |
| <i>Ivohibe</i>       | 16            | 34                | 50           |

|            | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 75           | 125   | 200                |       |              |   |                    |        |        |     |       |            |        |    |       |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------|--------------------|-------|--------------|---|--------------------|--------|--------|-----|-------|------------|--------|----|-------|
|            | <b>B/ Measurement H</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |              |       |                    |       |              |   |                    |        |        |     |       |            |        |    |       |
|            | 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: |              |       |                    |       |              |   |                    |        |        |     |       |            |        |    |       |
|            | $SCO_{30} = SCO_{0-10} + SCO_{10-20} + SCO_{20-30}$                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |       |                    |       |              |   |                    |        |        |     |       |            |        |    |       |
|            | The link to the document showing this equation is :                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |       |                    |       |              |   |                    |        |        |     |       |            |        |    |       |
|            | <a href="https://drive.google.com/file/d/1BplptFidsQYvn8pWp4CqxCGADq95nvVT/view?usp=drive_link">https://drive.google.com/file/d/1BplptFidsQYvn8pWp4CqxCGADq95nvVT/view?usp=drive_link</a>                                                                                                                                                                                                                                                                                                          |              |       |                    |       |              |   |                    |        |        |     |       |            |        |    |       |
|            | Les stocks de C à volume équivalent ont été principalement utilisés pour la cartographie et la modélisation du carbone du sol.                                                                                                                                                                                                                                                                                                                                                                     |              |       |                    |       |              |   |                    |        |        |     |       |            |        |    |       |
|            | <b>C/ Inference</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |       |                    |       |              |   |                    |        |        |     |       |            |        |    |       |
|            | 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                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |       |                    |       |              |   |                    |        |        |     |       |            |        |    |       |
|            | <table><tr><th>Class</th><th>SOC (tdm/ha)</th><th>N</th><th>Standard deviation</th></tr><tr><td>Forest</td><td>110.97</td><td>125</td><td>39.17</td></tr><tr><td>Non-Forest</td><td>104.65</td><td>75</td><td>37.53</td></tr></table>                                                                                                                                                                                                                                                              |              |       |                    | Class | SOC (tdm/ha) | N | Standard deviation | Forest | 110.97 | 125 | 39.17 | Non-Forest | 104.65 | 75 | 37.53 |
|            | 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:                              | <b>Class</b>                                                                                            | <b>Value</b>                    |  |
|                                             | 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                                         |                                 |  |
|                                             | <i>Class</i>                                                                                            | 90% level – confidence interval |  |
|                                             | <i>Forest</i>                                                                                           | 5%                              |  |
|                                             | <i>Non-Forest</i>                                                                                       | 7%                              |  |
| Any comment:                                |                                                                                                         |                                 |  |

### 3.2 Monitored Data and Parameters

|                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       |                       |
|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| Parameter :                                                | $A'(j, i), A'(i, j)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                       |
| Description :                                              | <ul style="list-style-type: none"> <li>Annual conversion from forest type j (primary forest, modified natural forest), to non-Forest Land uses i (Non-Forest) in the monitoring period</li> <li>Annual conversion from forest type j (primary forest), to forest type i (modified natural forest and plantations) in the monitoring period</li> <li>Annual conversion from non-Forest Land use i to forest type j (planted forest or modified natural forest) in the monitoring period</li> </ul> |                       |                       |
| Data unit :                                                | ha/year                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       |                       |
| Value monitored during this Monitoring / Reporting Period: | <b>Activity</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Type</b>           | <b>Area (ha/year)</b> |
|                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Dense humid forest    | <b>557.90</b>         |
|                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Degraded humid forest | <b>7,414.90</b>       |
|                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Secondary forest      | <b>253.82</b>         |

|                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |                  |
|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------------|
|                                                                                            | Deforestation <sup>†‡</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Agroforestry           | 0                |
|                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Plantations            | <b>84.61</b>     |
|                                                                                            | Degradation <sup>§ **</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | PF to Disturbed forest | <b>6, 911.57</b> |
|                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | PF to Agroforestry     | 0                |
|                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | PF to Plantations      | 0                |
|                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DF to Agroforestry     | 0                |
|                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DF to Plantations      | 0                |
|                                                                                            | Enhancement <sup>††</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Secondary forest       | 0                |
|                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Agroforestry           | 0                |
|                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Plantations            | 0                |
| Source of data and description of measurement/cal culation methods and procedures applied: | <p><u>Sampling design:</u> 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.</p> <p><u>Estimator:</u><br/>Stratified random estimator of a proportion</p> <p><u>Stratification:</u><br/>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 SOP0 (<a href="https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhlrSy7sbU_5m/view?usp=sharing">https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhlrSy7sbU_5m/view?usp=sharing</a>).</p> <p>* Stratification used for the activity data estimation</p> <div style="background-color: #e8f5e9; padding: 5px; margin-top: 10px;"> <p><b>Strata</b></p> <p>11- Forest</p> <p>12- Deforestation</p> </div> |                        |                  |

<sup>†</sup> <https://drive.google.com/file/d/1-JHFUSNXZY9982HNFQaxH44xKpJeThaC/view?usp=sharing> (refers to the file “deforestation\_2021-2022” for deforestation datas monitoring 2021-2022)

<sup>‡</sup> [https://drive.google.com/file/d/1jsbTW6O7K1HKxhCfwF38ZJy\\_s3VU8D4P/view?usp=sharing](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)

<sup>§</sup> <https://drive.google.com/file/d/1-JHFUSNXZY9982HNFQaxH44xKpJeThaC/view?usp=sharing> (refers to the file “degradation\_2021-2022” for degradation datas monitoring 2021-2022)

<sup>\*\*</sup> [https://drive.google.com/file/d/1jsbTW6O7K1HKxhCfwF38ZJy\\_s3VU8D4P/view?usp=sharing](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)

<sup>††</sup> [https://drive.google.com/file/d/1jsbTW6O7K1HKxhCfwF38ZJy\\_s3VU8D4P/view?usp=sharing](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 :

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

Where:

$W_h$  Weight of stratum  $i$ ;  
 $S_h$  Standard deviation of variable of interest in stratum  $i$ ;  
 $S(\hat{\theta})$  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 1,443 additional samples were added in all strata: 601 samples for strata 11, 18 samples for strata 12, and 824 samples for strata 55.
- The total number of samples analyzed was: 2793.

Sample allocation was based on an optimal approach.

(Samples estimation seen at the web address:

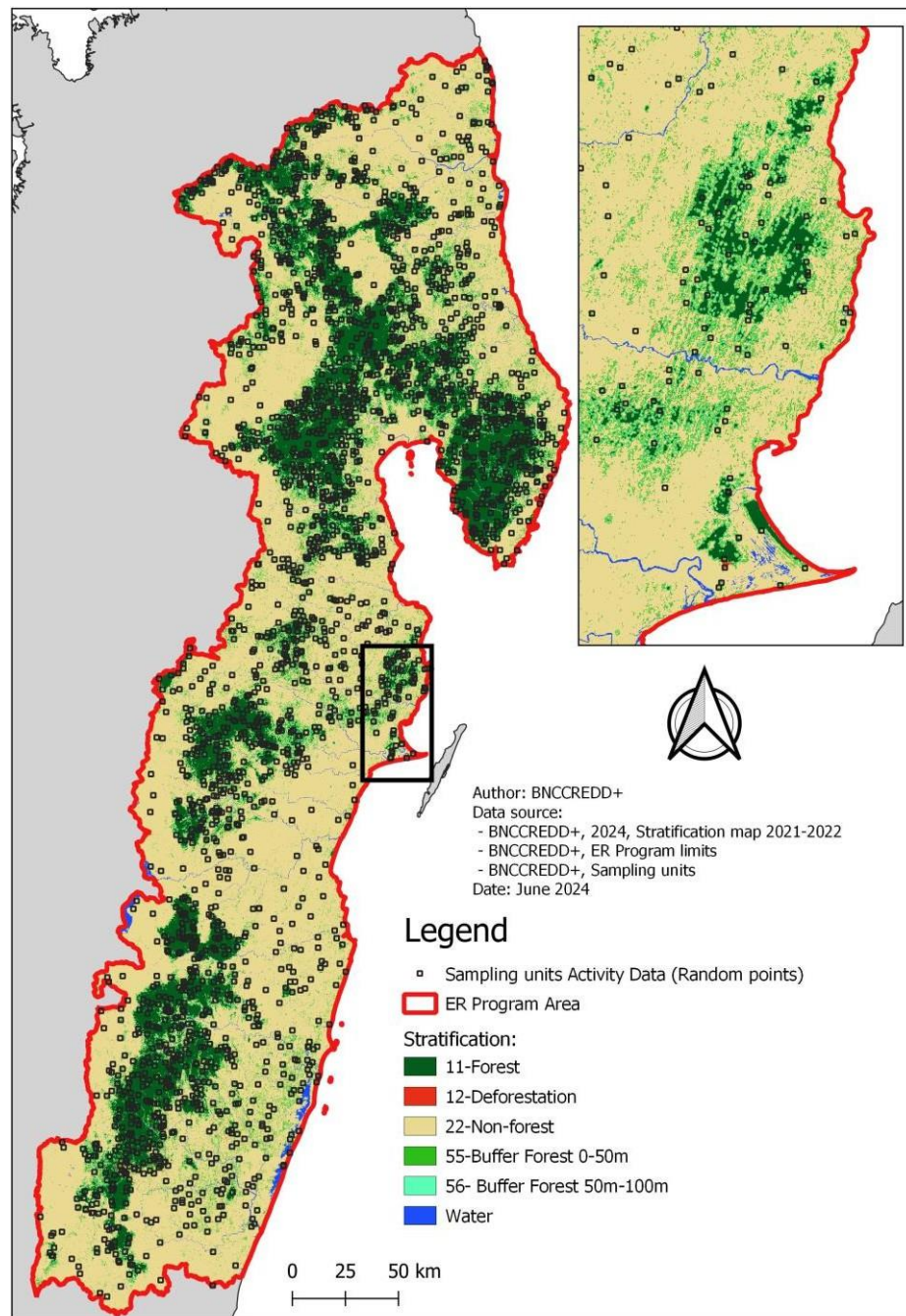
[https://docs.google.com/spreadsheets/d/1WpnTIIXAxBQUKcTfvmMWd8mQpsv\\_fkf/edit?usp=drive\\_link&ouid=104952608302722035338&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1WpnTIIXAxBQUKcTfvmMWd8mQpsv_fkf/edit?usp=drive_link&ouid=104952608302722035338&rtpof=true&sd=true)

)

Calculation of number of samples per stratum for the second monitoring report<sup>††</sup>

| Code | Class                  | Weight of strata | Number of samples |
|------|------------------------|------------------|-------------------|
| 11   | Stable Forest          | 0.1866984        | 901               |
| 12   | Deforestation          | 0.0040291        | 168               |
| 22   | Stable Non Forest      | 0.6735024        | 300               |
| 55   | Buffer Forest 50m-100m | 0.0888764        | 1124              |
| 56   | Buffer Forest 0m-50m   | 0.0362192        | 300               |

<sup>††</sup> [https://drive.google.com/file/d/1\\_7QpGzRqRnwZtaNrC605u1cCeF\\_Z8Die/view?usp=sharing](https://drive.google.com/file/d/1_7QpGzRqRnwZtaNrC605u1cCeF_Z8Die/view?usp=sharing) (refers to the determination of the sample size)



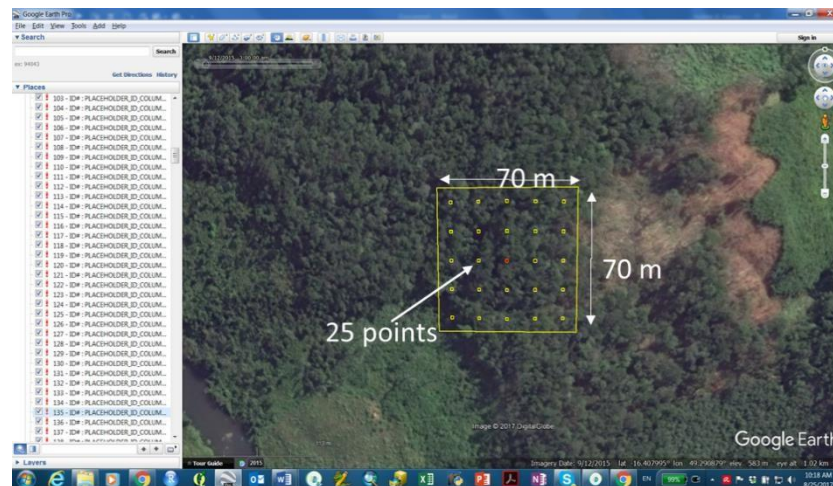
Location of sampling units and stratification

**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.

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:**

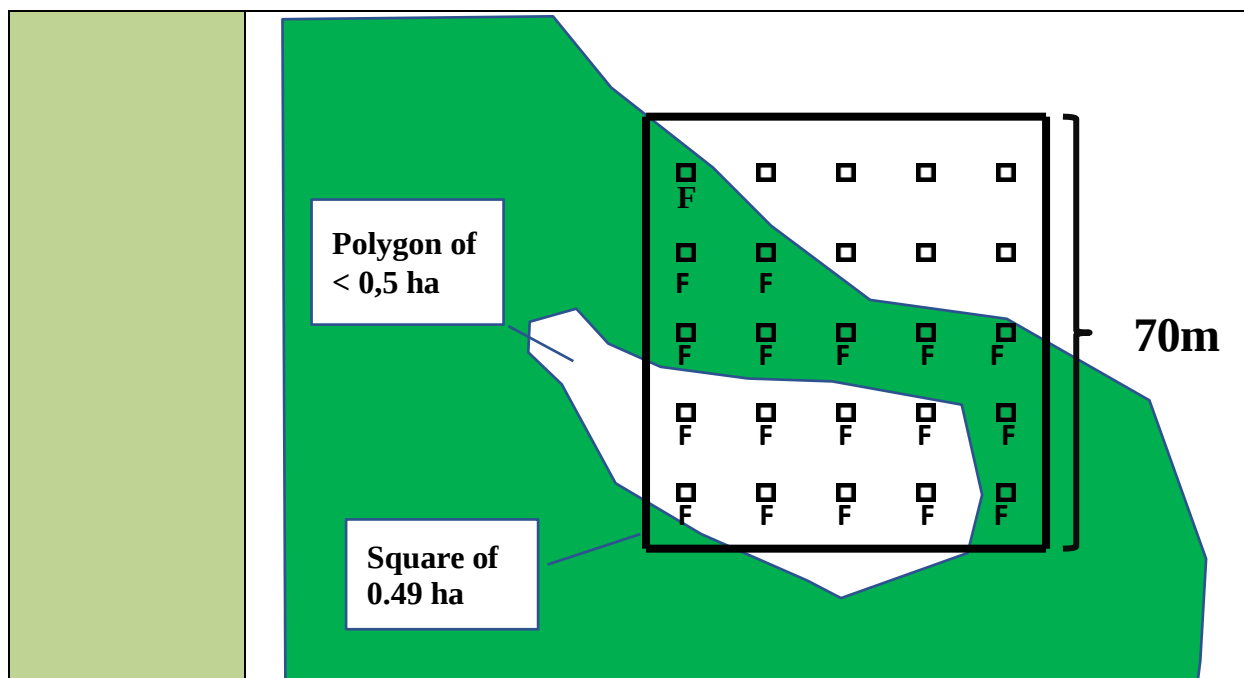
The data in this case was collected through visual interpretation of all satellite imagery available to the country:

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

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 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 found in this link ([https://drive.google.com/file/d/1Hs3BSGL69kK6\\_ELrvq5h5-\\_I0pDZtJTS/view?usp=sharing](https://drive.google.com/file/d/1Hs3BSGL69kK6_ELrvq5h5-_I0pDZtJTS/view?usp=sharing))

The results of the interpretation during the second monitoring report are the following:

Sampling units per strata

| Activity <sup>§§</sup> | Type             | Strata |    |    |    |    |
|------------------------|------------------|--------|----|----|----|----|
|                        |                  | 11     | 12 | 22 | 55 | 56 |
| Deforestation          | Primary forest   |        |    |    | 2  |    |
|                        | Disturbed forest | 1      | 79 |    | 15 |    |
|                        | Secondary forest |        | 3  |    |    |    |
|                        | Agroforestry     |        |    |    |    |    |
|                        | Plantations      |        | 1  |    |    |    |
| Enhancement            | Secondary forest |        |    |    |    |    |

|                                       |                        |     |    |   |    |   |
|---------------------------------------|------------------------|-----|----|---|----|---|
|                                       | Agroforestry           |     |    |   |    |   |
|                                       | Plantations            |     |    |   |    |   |
|                                       | PF to Disturbed forest | 6   |    |   | 6  | 2 |
|                                       | PF to Agroforestry     |     |    |   |    |   |
|                                       | PF to Plantation       |     |    |   |    |   |
| <b>Total number of sampling units</b> |                        | 7   | 83 | 0 | 23 | 2 |
| <b>Total</b>                          |                        | 115 |    |   |    |   |

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  $\hat{\mu}_h = \frac{1}{n_h} \sum_{k=1}^{n_h} y_{hk}$  where  $y_{hk}$  is the  $k^{th}$  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 6,980,308 ha.

§§ <https://drive.google.com/file/d/1-JHFUSNXZY9982HNFQaxH44xKpJeThaC/view?usp=sharing> ;  
[https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&oid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&oid=112106790342798073832&rtpof=true&sd=true)

Estimate of proportions per class

| <b>Activity</b>      | <b>Type</b>            | <b>Area estimate (ha)</b> |
|----------------------|------------------------|---------------------------|
| <i>Deforestation</i> | Dense humid forest     | 0.000159                  |
|                      | Degraded humid forest  | 0.002124                  |
|                      | Secondary forest       | 0.000072                  |
|                      | Agroforestry           | -                         |
|                      | Plantations            | 0.000024                  |
| <i>Enhancement</i>   | Secondary forest       | -                         |
|                      | Agroforestry           | -                         |
|                      | Plantations            | -                         |
| <i>Degradation</i>   | PF to Disturbed forest | 0.00198                   |
|                      | PF to Agroforestry     | -                         |
|                      | PF to Plantations      | -                         |
|                      | DF to Agroforestry     | -                         |
|                      | DF to Plantations      | -                         |

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

Estimate of activity data per class

| <b>Activity</b>      | <b>Type</b>            | <b>Area (ha/year)</b> |
|----------------------|------------------------|-----------------------|
| <i>Deforestation</i> | Dense humid forest     | 557.90                |
|                      | Degraded humid forest  | 7,414.90              |
|                      | Secondary forest       | 253.82                |
|                      | Agroforestry           |                       |
|                      | Plantations            | 84.61                 |
| <i>Degradation</i>   | PF to Disturbed forest | 6,911.57              |
|                      | PF to Agroforestry     | -                     |
|                      | PF to Plantations      | -                     |
|                      | DF to Agroforestry     | -                     |
|                      | DF to Plantations      | -                     |
| <i>Enhancement</i>   | Secondary forest       | -                     |
|                      | Agroforestry           | -                     |
|                      | Plantations            | -                     |

|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                        |                             |                                           |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-----------------------------|-------------------------------------------|
|                                 | More information is provided in the spreadsheet<br>“MADA_CalculRE_v00_20240617_update_for_ER_Report_2021_2022_v8” and<br><a href="https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPIuvS/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true">https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPIuvS/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                        |                             |                                           |
| QA/QC procedures applied:       | <p>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<br/>(<a href="https://drive.google.com/file/d/1Hs3BSGL69kK6_ELrvq5h5-I0pDZtJTS/view?usp=sharing">https://drive.google.com/file/d/1Hs3BSGL69kK6_ELrvq5h5-I0pDZtJTS/view?usp=sharing</a>,<br/><a href="https://drive.google.com/file/d/1Qf4PIgJvx03cISYtpbhC9_HboXIRP1go/view?usp=sharing">https://drive.google.com/file/d/1Qf4PIgJvx03cISYtpbhC9_HboXIRP1go/view?usp=sharing</a>)</p> <p>The labeling or assignment of a class to a sample is checked three times:</p> <ul style="list-style-type: none"><li>- 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.);</li><li>- 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;</li><li>- 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.</li></ul> |                        |                             |                                           |
| Uncertainty for this parameter: | Activity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Type                   | Standard error (proportion) | 90% confidence – Relative margin of error |
|                                 | Deforestation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Dense humid forest     | 0.000113                    | 116%                                      |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Degraded humid forest  | 0.000261                    | 20%                                       |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Secondary forest       | 0.000041                    | 94%                                       |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Agroforestry           | 0                           | 0                                         |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Plantations            | 0.000024                    | 164%                                      |
|                                 | Enhancement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Secondary forest       | -                           | -                                         |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Agroforestry           | -                           | -                                         |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Plantations            | -                           | -                                         |
|                                 | Degradation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | PF to Disturbed forest | 0.000573                    | 48%                                       |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | PF to Agroforestry     | -                           | -                                         |
| PF to Plantations               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | -                      | -                           |                                           |

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

## 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 <sub>2</sub> -e/yr) | If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO <sub>2</sub> -e/yr) | If applicable, average annual historical removals by sinks over the Reference Period (tCO <sub>2</sub> -e/yr) | Adjustment, if applicable (tCO <sub>2</sub> -e/yr) | Reference level (tCO <sub>2</sub> -e/yr)* |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------|
| 2021                                  | 11,477,239                                                                                                | 420,060                                                                                                                       | -26,508                                                                                                       |                                                    | 11,870,790                                |
| 2022                                  | 11,477,239                                                                                                | 420,060                                                                                                                       | -39,762                                                                                                       |                                                    | 11,857,536                                |
| <b>Total</b>                          | 22,954,477                                                                                                | 840,120                                                                                                                       | -66,270                                                                                                       |                                                    | 23,728,326                                |

\*Link :

[https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&oid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&oid=112106790342798073832&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 (SOP 0)<br>Calculation of stratum weight $W_h$<br>$W_h = \frac{\text{Area of stratum}}{\text{Total area}}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                 | Identification of number of samples                    | Use the formula from Cochran, 1977<br>$n = \left( \sum_{h=1}^H \frac{W_h S_h}{SE} \right)^2 = \frac{t^2}{E^2} \times \left( \sum_{h=1}^H W_h S_h \right)^2$<br>Where<br><ul style="list-style-type: none"> <li>- n is the number of samples</li> <li>- <math>W_h</math> the weight of stratum</li> <li>- <math>S_h</math> the standard error</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 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.<br>Definitions seen in this link :<br><a href="https://drive.google.com/file/d/1Zxwp4Vzsh9vjNnSVsCsLLs9TbR0RoeQn/view?usp=drive_link">https://drive.google.com/file/d/1Zxwp4Vzsh9vjNnSVsCsLLs9TbR0RoeQn/view?usp=drive_link</a><br>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.<br>The UOT (land use and cover classes changes) here gives the conversion from a class to another, e.g.: forest to non forest which 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<br>Step 1 : frequency of deforestation<br>Step 2 : evaluation of area of deforestation<br>Step 3 : evaluation of uncertainties                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

|                                        |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                        | Quantity of degradation                     | Step 1 : frequency of the estimator<br>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<br>Step 2 : evaluation of quantity of gain<br>Step 4 : uncertainties                                                                                                                                                                                                                                                                                                                                                                                         |
|                                        | Estimation of emission due to fire          | Step 1 : evaluation of frequency of fire<br>Step 2 : evaluation of area affected by fire<br>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<br>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_2021_2022_v6.1" and <a href="https://docs.google.com/spreadsheets/d/1zNsnTFV9SZT7i-xcJ9chGcQTBFIHD89/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true">https://docs.google.com/spreadsheets/d/1zNsnTFV9SZT7i-xcJ9chGcQTBFIHD89/edit?usp=drive_link&amp;ouid=112106790342798073832&amp;rtpof=true&amp;sd=true</a> ) |

### 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 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 ( $\hat{p}_{DEF}$ ). 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 ( $\hat{p}_{DEF}$ ), we multiply the weight of each stratum h ( $W_h$ ) by the proportion of each stratum h ( $\bar{p}_{h,DEF}$ )

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

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:

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

Where,  $t_{student}$  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  $W_i$  is the weight of each stratum,  $n_i$  is the number of samples in each stratum, and  $\hat{\sigma}_i^2$  is the sampling variance.

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

This variance is calculated with the following equation:

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

### 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<sup>†††</sup>) as “data\_with\_stratum\_preaa\_2122”<sup>†††</sup>

Area and weight of each stratum used in the “deforestation\_2021-2022”<sup>§§§</sup>

Area of ERPAA (calculated from the table above)

R script used to process that data “calcul\_defor\_gain\_for\_export\_2021\_2022.R” (link : [https://drive.google.com/file/d/1B8Ag28DIL1OTRzh3Is9fOP6KuDrzFn2O/view?usp=drive\\_link](https://drive.google.com/file/d/1B8Ag28DIL1OTRzh3Is9fOP6KuDrzFn2O/view?usp=drive_link)

) and “suivi\_2021\_2022.R” (link : [https://drive.google.com/file/d/1rVldLW3f3c4N09aolLfoWGSufRdKBWB/view?usp=drive\\_link](https://drive.google.com/file/d/1rVldLW3f3c4N09aolLfoWGSufRdKBWB/view?usp=drive_link)

\*\*\*

[https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&oid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&oid=112106790342798073832&rtpof=true&sd=true)

<sup>†††</sup> <https://drive.google.com/file/d/1bnMquy5pWkW96wMG00vhigodUWugjAGg/view?usp=sharing> (link to .csv and .zip files of the activity data during the monitoring 2021-2022)

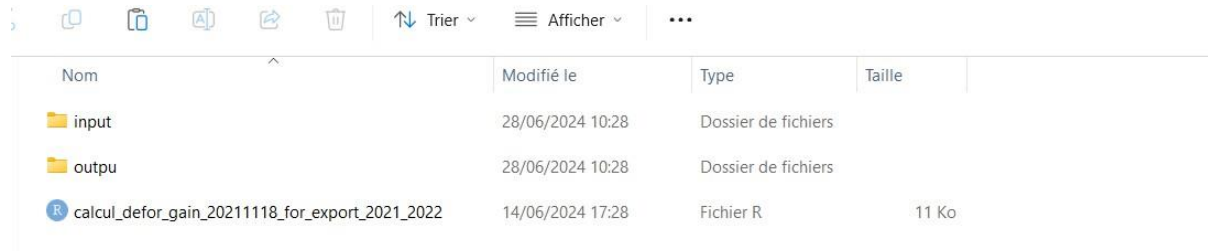
<sup>†††</sup> <https://drive.google.com/file/d/1NV9vqY-cAtnIK10xRemSTXRxRjGokz43/view?usp=sharing> (link to “data\_with\_stratum\_preaa2122” file)

<sup>§§§</sup> <https://drive.google.com/file/d/1-JHFUSNXZY9982HNFQaxH44xKpJeThaC/view?usp=sharing>

Excel spreadsheet MADA\_CalculRE\_v00\_20240617\_update\_for\_ER\_Report\_2021\_2022\_v8.xlsx, link : [https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&oid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&oid=112106790342798073832&rtpof=true&sd=true)

## Steps

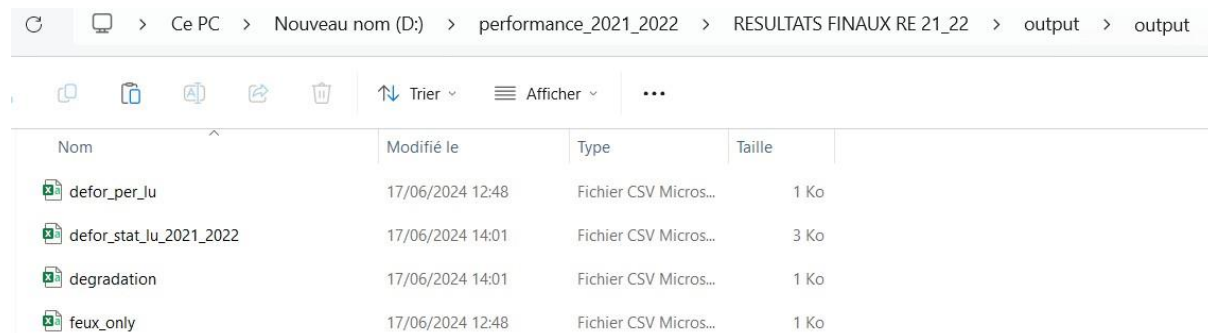
The script is designed to read input data from a folder input, and write results in folder output. The folder structure is then arranged so that the R script can find the input and output folder, and should then be arranged as in the picture below:



| Nom                                             | Modifié le       | Type                | Taille |
|-------------------------------------------------|------------------|---------------------|--------|
| input                                           | 28/06/2024 10:28 | Dossier de fichiers |        |
| output                                          | 28/06/2024 10:28 | Dossier de fichiers |        |
| calcul_defor_gain_20211118_for_export_2021_2022 | 14/06/2024 17:28 | Fichier R           | 11 Ko  |

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 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.



| Nom                     | Modifié le       | Type                  | Taille |
|-------------------------|------------------|-----------------------|--------|
| defor_per_lu            | 17/06/2024 12:48 | Fichier CSV Micros... | 1 Ko   |
| defor_stat_lu_2021_2022 | 17/06/2024 14:01 | Fichier CSV Micros... | 3 Ko   |
| degradation             | 17/06/2024 14:01 | Fichier CSV Micros... | 1 Ko   |
| feux_only               | 17/06/2024 12:48 | Fichier CSV Micros... | 1 Ko   |

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.

|    | A | B         | C         | D      | E          | F        | G          | H           | I          | J          | K       | L          |
|----|---|-----------|-----------|--------|------------|----------|------------|-------------|------------|------------|---------|------------|
| 1  |   | lu_level2 | lu_level3 | fq_abs | fq_rel     | variance | std_error  | uncertainty | area       | CI         | stratum | wh         |
| 2  |   | 1 FF      |           | 888    | 0,98557159 | 5,62E-07 | 0,00074971 | 0,00125163  | 1334199,59 | 1669,92291 | 11      | 0,18871284 |
| 3  |   | 2 FF      | FHI       | 6      | 0,00665927 | 2,61E-07 | 0,00051133 | 0,12634159  | 9014,86209 | 1138,95196 | 11      | 0,18871284 |
| 4  |   | 3 FG      | FHD       | 1      | 0,00110988 | 4,38E-08 | 0,00020933 | 0,31033566  | 1502,47701 | 466,272196 | 11      | 0,18871284 |
| 5  |   | 4 GG      |           | 6      | 0,00665927 | 2,61E-07 | 0,00051133 | 0,12634159  | 9014,86209 | 1138,95196 | 11      | 0,18871284 |
| 6  |   | 5 FF      |           | 34     | 0,20238095 | 1,59E-08 | 0,00012624 | 0,00102635  | 5912,45631 | 6,06826795 | 12      | 0,00407256 |
| 7  |   | 6 FG      | FHD       | 79     | 0,4702381  | 2,46E-08 | 0,00015682 | 0,00054874  | 13737,7661 | 7,53843927 | 12      | 0,00407256 |
| 8  |   | 7 FG      | FSS       | 3      | 0,01785714 | 1,73E-09 | 4,16E-05   | 0,00383412  | 521,687321 | 2,00020952 | 12      | 0,00407256 |
| 9  |   | 8 FG      | PLM       | 1      | 0,00595238 | 5,84E-10 | 2,42E-05   | 0,00668101  | 173,895774 | 1,16179934 | 12      | 0,00407256 |
| 10 |   | 9 GG      |           | 50     | 0,29761905 | 2,06E-08 | 0,00014366 | 0,00079422  | 8694,78869 | 6,90555991 | 12      | 0,00407256 |
| 11 |   | 10 GG     | SSher     | 1      | 0,00595238 | 5,84E-10 | 2,42E-05   | 0,00668101  | 173,895774 | 1,16179934 | 12      | 0,00407256 |
| 12 |   | 11 FF     |           | 7      | 0,02333333 | 3,52E-05 | 0,00593336 | 0,41840371  | 113948,328 | 47676,4031 | 22      | 0,68076934 |
| 13 |   | 12 GG     |           | 289    | 0,96333333 | 5,46E-05 | 0,00738692 | 0,01261706  | 4704438,09 | 59356,1764 | 22      | 0,68076934 |
| 14 |   | 13 WW     |           | 4      | 0,01333333 | 2,03E-05 | 0,0045081  | 0,55632247  | 65113,33   | 36224,0083 | 22      | 0,68076934 |
| 15 |   | 14 FF     |           | 758    | 0,67437722 | 1,58E-06 | 0,00125566 | 0,00306367  | 434591,491 | 1331,44283 | 55      | 0,08983532 |
| 16 |   | 15 FF     | FHI       | 6      | 0,00533808 | 3,81E-08 | 0,00019525 | 0,06018394  | 3440,03819 | 207,035064 | 55      | 0,08983532 |
| 17 |   | 16 FG     | FHD       | 15     | 0,0133452  | 9,45E-08 | 0,00030747 | 0,03791015  | 8600,09546 | 326,030913 | 55      | 0,08983532 |
| 18 |   | 17 FG     | FHI       | 2      | 0,00177936 | 1,28E-08 | 0,00011293 | 0,10442796  | 1146,6794  | 119,74539  | 55      | 0,08983532 |
| 19 |   | 18 GG     |           | 340    | 0,3024911  | 1,51E-06 | 0,00123082 | 0,00669505  | 194935,497 | 1305,10324 | 55      | 0,08983532 |
| 20 |   | 19 GG     | SSher     | 1      | 0,00088968 | 6,38E-09 | 7,99E-05   | 0,14774924  | 573,339698 | 84,710502  | 55      | 0,08983532 |
| 21 |   | 20 GW     | SZar      | 1      | 0,00088968 | 6,38E-09 | 7,99E-05   | 0,14774924  | 573,339698 | 84,710502  | 55      | 0,08983532 |
| 22 |   | 21 WW     |           | 1      | 0,00088968 | 6,38E-09 | 7,99E-05   | 0,14774924  | 573,339698 | 84,710502  | 55      | 0,08983532 |
| 23 |   | 22 FF     |           | 292    | 0,97333333 | 1,16E-07 | 0,00034053 | 0,00057566  | 255618,26  | 147,148313 | 56      | 0,03660995 |
| 24 |   | 23 FF     | FHI       | 2      | 0,00666667 | 2,96E-08 | 0,00017201 | 0,04245247  | 1750,81    | 74,3262118 | 56      | 0,03660995 |
| 25 |   | 24 GG     |           | 6      | 0,02       | 8,76E-08 | 0,00029592 | 0,02434489  | 5252,43    | 127,869851 | 56      | 0,03660995 |

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

$$Pi (Estimate) = \sum_i^n ((Relative\ frequency\ of\ stratum) \times (Weight\ of\ the\ stratum))$$

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

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

Gain\_stat\_lu.csv contains the gain (regeneration, reforestation), with all the statistics like the above, and calculation of the estimate is the same. Only for this case, there are no records of gain, so all parameters are just zero (0).

## **USE OF PARAMETERS (ACTIVITY DATA AND EMISSION FACTORS) FOR THE CALCULATION OF EMISSION MONITORING :**

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

[https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true)

### **\*Identification of monitoring periods**

First, identify the years of emissions tracking. Here, it is the year 2021-2022

### **\*Definition of REDD+ activities considered (deforestation, degradation, enhancement, etc)**

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 ([https://drive.google.com/file/d/1ySgscvtfmb\\_tDvmdKFZNhIrSy7sbU\\_5m/view?usp=sharing](https://drive.google.com/file/d/1ySgscvtfmb_tDvmdKFZNhIrSy7sbU_5m/view?usp=sharing))
- The SOP on sampling (<https://drive.google.com/file/d/1fNh6rQX8L48Y9m6Sj3hLtL7U4Q-OXI9K/view?usp=sharing>)
- The SOP on data interpretation (response system) ([https://drive.google.com/file/d/1Hs3BSGL69kK6\\_ELrvq5h5-\\_lOpDZtJTS/view?usp=sharing](https://drive.google.com/file/d/1Hs3BSGL69kK6_ELrvq5h5-_lOpDZtJTS/view?usp=sharing))
- The SOP on data collection ([https://drive.google.com/file/d/1Qf4PIgixv03clSYtpbhC9\\_HboXIRP1go/view?usp=sharing](https://drive.google.com/file/d/1Qf4PIgixv03clSYtpbhC9_HboXIRP1go/view?usp=sharing))
- The SOP on data Analysis ([https://drive.google.com/file/d/1\\_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing](https://drive.google.com/file/d/1_Vke8Y5kvrMaUoa9RWZtV8kLhcSOaFGf/view?usp=sharing))

Link to FCPF forms including the data reported for the second reporting period:

[https://drive.google.com/file/d/1ziRgEpZqB-buNmrc2\\_Xs8YoPFyOyg\\_PH/view?usp=sharing](https://drive.google.com/file/d/1ziRgEpZqB-buNmrc2_Xs8YoPFyOyg_PH/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)

|    | A  | B         | C         | D      | E          | F        | G          | H           | I          | J          | K       | L          |
|----|----|-----------|-----------|--------|------------|----------|------------|-------------|------------|------------|---------|------------|
| 1  |    | lu_level2 | lu_level3 | fq_abs | fq_rel     | variance | std_error  | uncertainty | area       | CI         | stratum | wh         |
| 2  | 1  | FF        |           | 888    | 0,98557159 | 5,62E-07 | 0,00074971 | 0,00125163  | 1334199,59 | 1669,92291 | 11      | 0,18871284 |
| 3  | 2  | FF        | FHI       | 6      | 0,00665927 | 2,61E-07 | 0,00051133 | 0,12634159  | 9014,86209 | 1138,95196 | 11      | 0,18871284 |
| 4  | 3  | FG        | FHD       | 1      | 0,00110988 | 4,38E-08 | 0,00020933 | 0,31033566  | 1502,47701 | 466,272196 | 11      | 0,18871284 |
| 5  | 4  | GG        |           | 6      | 0,00665927 | 2,61E-07 | 0,00051133 | 0,12634159  | 9014,86209 | 1138,95196 | 11      | 0,18871284 |
| 6  | 5  | FF        |           | 34     | 0,20238095 | 1,59E-08 | 0,00012624 | 0,00102635  | 5912,45631 | 6,06826795 | 12      | 0,00407256 |
| 7  | 6  | FG        | FHD       | 79     | 0,4702381  | 2,46E-08 | 0,00015682 | 0,00054874  | 13737,7661 | 7,53843927 | 12      | 0,00407256 |
| 8  | 7  | FG        | FSS       | 3      | 0,01785714 | 1,73E-09 | 4,16E-05   | 0,00383412  | 521,687321 | 2,00020952 | 12      | 0,00407256 |
| 9  | 8  | FG        | PLM       | 1      | 0,00595238 | 5,84E-10 | 2,42E-05   | 0,00668101  | 173,895774 | 1,16179934 | 12      | 0,00407256 |
| 10 | 9  | GG        |           | 50     | 0,29761905 | 2,06E-08 | 0,00014366 | 0,00079422  | 8694,78869 | 6,90555991 | 12      | 0,00407256 |
| 11 | 10 | GG        | SSher     | 1      | 0,00595238 | 5,84E-10 | 2,42E-05   | 0,00668101  | 173,895774 | 1,16179934 | 12      | 0,00407256 |
| 12 | 11 | FF        |           | 7      | 0,02333333 | 3,52E-05 | 0,00593336 | 0,41840371  | 113948,328 | 47676,4031 | 22      | 0,68076934 |
| 13 | 12 | GG        |           | 289    | 0,96333333 | 5,46E-05 | 0,00738692 | 0,01261706  | 4704438,09 | 59356,1764 | 22      | 0,68076934 |
| 14 | 13 | WW        |           | 4      | 0,01333333 | 2,03E-05 | 0,0045081  | 0,55632247  | 65113,33   | 36224,0083 | 22      | 0,68076934 |
| 15 | 14 | FF        |           | 758    | 0,67437722 | 1,58E-06 | 0,00125566 | 0,00306367  | 434591,491 | 1331,44283 | 55      | 0,08983532 |
| 16 | 15 | FF        | FHI       | 6      | 0,00533808 | 3,81E-08 | 0,00019525 | 0,06018394  | 3440,03819 | 207,035064 | 55      | 0,08983532 |
| 17 | 16 | FG        | FHD       | 15     | 0,0133452  | 9,45E-08 | 0,00030747 | 0,03791015  | 8600,09546 | 326,030913 | 55      | 0,08983532 |
| 18 | 17 | FG        | FHI       | 2      | 0,00177936 | 1,28E-08 | 0,00011293 | 0,10442796  | 1146,6794  | 119,74539  | 55      | 0,08983532 |
| 19 | 18 | GG        |           | 340    | 0,3024911  | 1,51E-06 | 0,00123082 | 0,00669505  | 194935,497 | 1305,10324 | 55      | 0,08983532 |
| 20 | 19 | GG        | SSher     | 1      | 0,00088968 | 6,38E-09 | 7,99E-05   | 0,14774924  | 573,339698 | 84,710502  | 55      | 0,08983532 |
| 21 | 20 | GW        | SZar      | 1      | 0,00088968 | 6,38E-09 | 7,99E-05   | 0,14774924  | 573,339698 | 84,710502  | 55      | 0,08983532 |
| 22 | 21 | WW        |           | 1      | 0,00088968 | 6,38E-09 | 7,99E-05   | 0,14774924  | 573,339698 | 84,710502  | 55      | 0,08983532 |
| 23 | 22 | FF        |           | 292    | 0,97333333 | 1,16E-07 | 0,00034053 | 0,00057566  | 255618,26  | 147,148313 | 56      | 0,03660995 |
| 24 | 23 | FF        | FHI       | 2      | 0,00666667 | 2,96E-08 | 0,00017201 | 0,04245247  | 1750,81    | 74,3262118 | 56      | 0,03660995 |
| 25 | 24 | GG        |           | 6      |            | 8,76E-08 | 0,00029592 | 0,02434489  | 5252,43    | 127,869851 | 56      | 0,03660995 |

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 =  $f_{q\_rel} * w_h$

$f_{q\_rel}$  = relative frequency

$w_h$  = 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                        | 6980308,19  |             |              |               |
| t                                 | 1,645       |             |              |               |
|                                   |             |             |              |               |
|                                   |             |             |              |               |
| <b>lu category</b>                | <b>FHI</b>  | <b>FHD</b>  | <b>FSS</b>   | <b>PLM</b>    |
| Stratified estimate               | 0,00016     | 0,0021      | 0,000073     | 0,000024      |
| Variance                          | 0,000000013 | 0,000000068 | 0,0000000017 | 0,00000000058 |
| Standard error                    | 0,00011     | 0,00026     | 0,000042     | 0,000024      |
| Margin of error (90% CI)          | 0,00019     | 0,00043     | 0,00007      | 0,00004       |
| Relative Margin of error (90% CI) | 1,16440     | 0,20252     | 0,94092      | 1,64005       |
| Area (ha)                         | 1115,80     | 14829,80    | 507,64       | 169,21        |

\* 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  $f_{req\_rel}$  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) (cf link :

[https://docs.google.com/spreadsheets/d/1vSxK577AX1WNDap0K8CbYtCGgoDT6OIV/edit?usp=drive\\_link&oid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1vSxK577AX1WNDap0K8CbYtCGgoDT6OIV/edit?usp=drive_link&oid=112106790342798073832&rtpof=true&sd=true))

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 :

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

with :

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

$\rho$  : infra density of wood (t/m<sup>3</sup>)

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/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&ouid=112106790342798073832&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 (tCO<sub>2</sub>-e/yr) » and line 111, here it is the value 7,813,182 tCO<sub>2</sub>/year.

It should be noted that the calculation of emissions per REDD+ activity follows the formula :

Emission (tCO<sub>2</sub>/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 CO<sub>2</sub> emitted when clearing 1 ha of forest, expressed in tCO<sub>2</sub>/ha and follows the following formula:

**EF<sub>j</sub>** = (Biomass Before,<sub>j</sub> - Biomass After,<sub>j</sub>) x **CF** X

44/12 With

**EF<sub>j</sub>** : Emission factor for transition j in tons CO<sub>2</sub> ha<sup>-1</sup>.

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

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

**CF** : Fraction of carbon in dry biomass.

44/12 : Carbon expansion factor at CO<sub>2</sub>.

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

[https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&ouid=112106790342798073832&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 of the Monte Carlo file) (Link :

[https://docs.google.com/spreadsheets/d/1zNsnTFYV9SZT7i-xcJ9chGcQTBFIHD89/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1zNsnTFYV9SZT7i-xcJ9chGcQTBFIHD89/edit?usp=drive_link&ouid=112106790342798073832&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 = 7,322,128 + 491,054 - 0 = 7,813,182 tCO<sub>2</sub>e/year

| Year of Monitoring/Reporting Period | Emissions from deforestation (tCO <sub>2</sub> -e/yr) | If applicable, emissions from forest degradation (tCO <sub>2</sub> -e/yr)* | If applicable, removals by sinks (tCO <sub>2</sub> -e/yr) | Net emissions and removals (tCO <sub>2</sub> -e/yr) |
|-------------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------|
| 2021                                | 3,661,064                                             | 245,527                                                                    | 0                                                         | 3,906,591                                           |
| 2022                                | 3,661,064                                             | 245,527                                                                    | 0                                                         | 3,906,591                                           |
| <b>Total</b>                        | 7,322,128                                             | 491,054                                                                    | 0                                                         | 7,813,182                                           |

### 4.3 Calculation of emission reductions

|                                                                                             | Deforestation | If applicable, forest degradation | If applicable, enhanced removals from afforestation/ reforestation (A/R) | If applicable, enhanced removals from other activities besides A/R* | Total (tCO <sub>2</sub> -e) |
|---------------------------------------------------------------------------------------------|---------------|-----------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------|
| Emission or removals in the Reference Level (tCO <sub>2</sub> -e)                           | 22,954,477    | 840,119                           |                                                                          | -66,270                                                             | 23,728,326                  |
| Emission or removals under the ER Program during the Reporting Period (tCO <sub>2</sub> -e) | 7,322,128     | 491,054                           |                                                                          | 0                                                                   | 7,813,182                   |
| Emission Reductions during the Reporting Period (tCO <sub>2</sub> -e)                       | 15,632,349    | 349,065                           |                                                                          | -66,270                                                             | 15,915,144                  |

The values reported for enhance removals for the second reporting period are zero because of the short monitoring period (from 2020 to 2022). As such it was impossible to detect forest gain.

Also, it is important to highlight that given that the reference level was corrected, the correction resulted in additional gross emission reductions for the first monitoring period equivalent to 26,852 tCO<sub>2</sub>e. See below table.

| Year<br>s | REFERENCE LEVEL |            | EMISSIONS AND REMOVALS |           | GROSS ERs |           | Difference<br>ERs |
|-----------|-----------------|------------|------------------------|-----------|-----------|-----------|-------------------|
|           | BEFORE          | AFTER      | BEFORE                 | AFTER     | BEFORE    | AFTER     |                   |
| 2020      | 11,849,654      | 11,884,044 | 8,438,127              | 8,438,127 | 2,663,796 | 2,690,648 | 26,852            |

As agreed with the FMT these additional ERs will be claimed as part of the second reporting period. For this reason the total gross ERs to be reported here are (15,915,144 + 26,852) = 15,941,996 tCO<sub>2</sub>e. ( See Reduction d'emissions sheet, column E, line 117 in, the Excel file entitled MADA Calcul RE and the link [https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&oid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&oid=112106790342798073832&rtpof=true&sd=true)

## 5. UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

There is no pro-rata approach for this period. The monitoring period covers 730 days of 2021 and 2022. 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? |
|------------------------|------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------------|---------------------------------|
| <b>Activity Data</b>   |            |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                     |                           |                                 |
| Measurement            | ✓          | ✓      | <p>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 :</p> <ul style="list-style-type: none"> <li>Written standard operating procedures including detailed labeling protocols;</li> </ul> <p>Indeed, there are 5 standard operating procedures that have been written, including a specific one that defines labeling, namely POS2.</p> <p>SOP2s are 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.</p> <ul style="list-style-type: none"> <li>Use of adequate imaging source and multiple imaging sources for labeling;</li> </ul> | 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? |
|------------------------|------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------------------|---------------------------------|
|                        |            |        | <p>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.</p> <ul style="list-style-type: none"> <li>Procedures for training interpreters to ensure proper implementation of SOPs;</li> </ul> <p>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.</p> <ul style="list-style-type: none"> <li>Reinterpretation of a number of sample units to ensure that SOPs are properly implemented and to identify areas for improvement.</li> </ul> <p>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.</p> <p>/</p> |                                     |                          |                                 |
| 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? |
|------------------------|------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------------------|---------------------------------|
| <i>Sampling</i>        | x          | ✓      | <p>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 MGD. For 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.</p> <p>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, gain). From this stratification map, the sampling units were generated.</p> <p>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_v7_20240628.xlsx), the iteration continues until the optimal uncertainty is obtained. The link is <a href="https://docs.google.com/spreadsheets/d/1WLPL87UWgDoAuF_HzD01ydNOQmgFnRSN/edit?usp=drive_link&amp;oid=112106790342798073832&amp;rtpof=true&amp;sd=true">https://docs.google.com/spreadsheets/d/1WLPL87UWgDoAuF_HzD01ydNOQmgFnRSN/edit?usp=drive_link&amp;oid=112106790342798073832&amp;rtpof=true&amp;sd=true</a></p> | <i>High (random / bias)</i>         | YES                      | YES                             |
| <i>Extrapolation</i>   | ✓          | x      | Not applicable since no extrapolation was done, i.e. activity data was estimated directly through the sampling approach without using auxiliary data.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <i>L (bias)</i>                     | YES                      | NO                              |
| <i>Approach 3</i>      | ✓          | 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <i>L (bias)</i>                     | YES                      | NO                              |

| Sources of uncertainty  | Systematic | Random | Analysis of contribution to overall uncertainty                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Contribution to overall uncertainty | Addressed through QA/QC ? | Residual uncertainty estimated? |
|-------------------------|------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------------|---------------------------------|
|                         |            |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                     |                           |                                 |
| <b>Emission factor</b>  |            |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                     |                           |                                 |
| <i>DBH measurement</i>  | ✓          | ✓      | <p>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.</p> <p>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</p> <p>The height is measured using a hypsometer or vertex, following the instructions of the instrument. It can be raised with Bitterlich's Relascope</p> <p>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.</p> <p>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.</p> <p>The forest inventory guidelines are available on these links :<br/> <a href="https://drive.google.com/file/d/1AGrybPnC5Z4Xoxlb-HA_Z5c_q7m6UJoV/view?usp=drive_link">https://drive.google.com/file/d/1AGrybPnC5Z4Xoxlb-HA_Z5c_q7m6UJoV/view?usp=drive_link</a> and<br/> <a href="https://drive.google.com/file/d/11kTLBR1Me7KAp8j7F4UOdnKuTSGWaMsh/view?usp=drive_link">https://drive.google.com/file/d/11kTLBR1Me7KAp8j7F4UOdnKuTSGWaMsh/view?usp=drive_link</a></p> <p>Ref: BNCCREDD+. 2020, Terrestrial Forest Inventory Manual. 25 pages. Antananarivo. Madagascar</p> <p>Measurement errors are minimized by :</p> <ul style="list-style-type: none"> <li>- The establishment of a clear and precise inventory manual (BNCCREDD+. 2020, Terrestrial forest inventory manual. 25 pages. Antananarivo. Madagascar)</li> </ul> | H (bias) & L (random)               | YES                       | NO                              |
| <i>H measurement</i>    | ✓          | ✓      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | H (bias) & L (random)               | YES                       | NO                              |
| <i>Plot delineation</i> | ✓          | ✓      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 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? |
|--------------------------|------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------------|---------------------------------|
|                          |            |        | <ul style="list-style-type: none"> <li>- The recruitment of experienced staff for the inventory</li> <li>- The training of technicians and preparatory meeting before field missions</li> <li>- The use of adequate and standard equipment with all missions to minimize errors caused by instruments</li> </ul> <p>By quality controls carried out on random plots</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                     |                           |                                 |
| Wood density estimation  | ✓          | ✓      | WSG (Wood Specific Gravity) values used expressed in g/cm <sup>3</sup> 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 | ✓          | ✓      | <p>The allometric model error can be divided in the following sources.</p> <ul style="list-style-type: none"> <li>a. the error due to the uncertainty of the model's coefficients.</li> <li>b. the error linked to the residual model error;</li> <li>c. the selection of the allometric model.</li> </ul> <p>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 to 35% 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,</p> | 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.                                                                                                                                                                                                                                                                                                                                                                  |                                     |                           |                                 |
| <i>Sampling</i>                                                       | 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.                                                                                                                                                                                                                                               | <i>H (random / bias)</i>            | YES                       | YES                             |
| <i>Other parameters (e.g. Carbon Fraction , root-to-shoot ratios)</i> | ✓          | ✓      | 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.                                                                                                                                                                                                                                                                                                         | <i>H (bias / random )</i>           | YES                       | YES                             |
| <i>Representativeness</i>                                             | ✓          | 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.                                                                        | <i>Low (bias)</i>                   | YES                       | NO                              |
| <b>Integration</b>                                                    |            |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                     |                           |                                 |
| <i>Model</i>                                                          | ✓          | 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 | <i>Low (bias)</i>                   | 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).<br>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)     | 2,750.24/ SE 663.13    | 663.13                                                                            | Normal                            | above zero  |
| Annual deforestation disturbed forest (ha/year)   | 22,518.47/ SE 1,877.70 | 1,877.70                                                                          | Normal                            | above zero  |
| Annual deforestation secondary forest (ha/year)   | 160.55/ SE 160.55      | 160.55                                                                            | Normal                            | above zero  |
| Annual deforestation agroforestry (ha/year)       | 160.55/ SE 160.55      | 160.55                                                                            | 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) | 809.72/SE 356          | 356                                                                               | Normal                            | above zero  |

|                                                                 |                        |                |         |               |
|-----------------------------------------------------------------|------------------------|----------------|---------|---------------|
| 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) | 11,824.64/ SE 1,355.30 | 1,368.14       | 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 6.26       | 6.26           | Normal  | above zero    |
| SOCafter (tC/ha)                                                | 104.65 / SE 6.13       | 6.13           | Normal  | above zero    |
| FMG Deforestation (dimensionless)                               | 1.22 / SE 0.09         | 0.09           | Normal  | above zero    |
| FI Deforestation (dimensionless)                                | 0.92 / SE 0.13         | 0.13           | 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            |
| <b>MONITORING</b>                                                                              |                          |               |         |               |
| Annual deforestation primary forest (ha/year)                                                  | <b>557.90</b>            | <b>394.87</b> | Normal  | Above zero    |

|                                                                       |                 |                |        |            |
|-----------------------------------------------------------------------|-----------------|----------------|--------|------------|
| Annual deforestation<br>disturbed forest (ha/year)                    | <b>7,414.90</b> | <b>912.79</b>  | Normal | Above zero |
| Annual deforestation<br>secondary forest (ha/year)                    | <b>253.82</b>   | <b>145.17</b>  | Normal | Above zero |
| Annual deforestation<br>agroforestry (ha/year)                        | <b>0.00</b>     | <b>0.00</b>    | Normal | Above zero |
| Annual deforestation<br>plantation (ha/year)                          | <b>84.61</b>    | <b>84.34</b>   | Normal | Above zero |
| Annual forest regrowth-<br>Forest gain-secondary forest<br>(ha/year)  | <b>0.00</b>     | <b>0.00</b>    | Normal | Above zero |
| Annual forest regrowth-<br>Forest gain-agroforestry<br>(ha/year)      | <b>0.00</b>     | <b>0.00</b>    | Normal | Above zero |
| Annual forest regrowth-<br>Forest gain-plantation<br>(ha/year)        | <b>0.00</b>     | <b>0.00</b>    | Normal | Above zero |
| Annual degradation-Primary<br>forest to disturbed forest<br>(ha/year) | <b>6,911.57</b> | <b>2002.41</b> | Normal | Above zero |
| Annual degradation-Primary<br>forest to agroforestry<br>(ha/year)     | <b>0.00</b>     | <b>0.00</b>    | Normal | Above zero |
| Annual degradation-Primary<br>forest to plantation<br>(ha/year)       | <b>0.00</b>     | <b>0.00</b>    | Normal | Above zero |
| Annual degradation-<br>Disturbed forest to<br>agroforestry (ha/year)  | <b>0.00</b>     | <b>0.00</b>    | Normal | Above zero |
| Annual degradation-<br>Disturbed forest to<br>plantation (ha/year)    | <b>0.00</b>     | <b>0.00</b>    | Normal | Above zero |

**Quantification of the uncertainty of the estimate of Emission Reductions**

(link : [https://docs.google.com/spreadsheets/d/1zNsnTFYV9SZT7i-xcJ9chGcQTBFIHD89/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1zNsnTFYV9SZT7i-xcJ9chGcQTBFIHD89/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true))

|   |                                                   | Reporting Period           |                     | Crediting Period           |                     |
|---|---------------------------------------------------|----------------------------|---------------------|----------------------------|---------------------|
|   |                                                   | Total Emission Reductions* | Forest degradation* | Total Emission Reductions* | Forest degradation* |
| A | Median                                            | 16,601,592                 | NA                  | 20,460,033                 | NA                  |
| B | Upper bound 90% CI (Percentile 0.95)              | 20,937,007                 | NA                  | 25,322,498                 | NA                  |
| C | Lower bound 90% CI (Percentile 0.05)              | 12,784,398                 | NA                  | 15,997,881                 | NA                  |
| D | Half Width Confidence Interval at 90% (B – C) / 2 | 4,076,304                  | NA                  | 4,662,308                  | NA                  |
| E | Relative margin (D / A)                           | 25%                        | NA                  | 23%                        | NA                  |
| F | Uncertainty discount                              | 4%                         | NA                  | 4%                         | NA                  |

\*Remove forest degradation from the estimate if forest degradation has been estimated with proxy data.

\*\*Remove the column if forest degradation has not been estimated using proxy data.

The value of Emissions Reduction during the reporting period (tCO<sub>2</sub>-e), at 15,941,966 lies well within the upper and lower bounds of the 90% confidence interval of the second report ER MC. This value can be seen in the RE calculation file (cf link :

[https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1pYtVITN53gxbRaRsYyeKepoBMkkPluvS/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true) , Emissions reduction sheet, column B, line 113).

In addition, the value of Emissions Reduction during the crediting period (tCO<sub>2</sub>-e), which is 15,941,966 + 2,663,796 = 18,605,792, also lies between the two values of the MC's 90% confidence interval for the entire RE of the first and second reports. (cf Monte Carlo file in the link below, REL sheet)

Link Monte Carlo :

[https://docs.google.com/spreadsheets/d/1zNsnTFYV9SZT7i-xcJ9chGcQTBFHd89/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1zNsnTFYV9SZT7i-xcJ9chGcQTBFHd89/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true)

### 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](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  | 15                 | -10                                                |
| No reference level Degradation    | 27                 | +2                                                 |
| No reference level Enhancement    | 25                 | 0                                                  |
| No Emission factor                | 21                 | -4                                                 |
| No Root to shoot ratio            | 25                 | 0                                                  |
| No monitoring level deforestation | 28                 | +3                                                 |
| No monitoring level degradation   | 25                 | 0                                                  |
| No monitoring level Enhancement   | 25                 | 0                                                  |

The results of the sensitivity analysis are presented in the tables below (with a link showing the calculation : [https://docs.google.com/spreadsheets/d/1DWOHDI0GPx\\_9ye5ueKF7IXE0JRQ\\_hNgz/edit?usp=drive\\_link&ouid=112106790342798073832&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1DWOHDI0GPx_9ye5ueKF7IXE0JRQ_hNgz/edit?usp=drive_link&ouid=112106790342798073832&rtpof=true&sd=true) ) :

|                             |                                                          |                  |
|-----------------------------|----------------------------------------------------------|------------------|
| <b>ER 2nd report (year)</b> | All parameters                                           |                  |
|                             | <b>Value calculated MC tool</b>                          | <b>7,970,670</b> |
| A                           | <b>Median</b>                                            | <b>8,279,591</b> |
| B                           | <b>Upper bound 90% CI (Percentile 0.95)</b>              | 10,499,544       |
| C                           | <b>Lower bound 90% CI (Percentile 0.05)</b>              | 6,386,016        |
| D                           | <b>Half Width Confidence Interval at 90% (B – C) / 2</b> | 2,056,764        |
| E                           | <b>Relative margin (D / A)</b>                           | 25%              |

|                             |                                  |                  |
|-----------------------------|----------------------------------|------------------|
| <b>ER 2nd report (year)</b> | No reference level Deforestation |                  |
|                             | <b>Value calculated MC tool</b>  | <b>7,970,670</b> |
| A                           | <b>Median</b>                    | <b>6,939,473</b> |

|   |                                                   |           |
|---|---------------------------------------------------|-----------|
| B | Upper bound 90% CI (Percentile 0.95)              | 7,929,738 |
| C | Lower bound 90% CI (Percentile 0.05)              | 5,873,643 |
| D | Half Width Confidence Interval at 90% (B – C) / 2 | 1,028,048 |
| E | Relative margin (D / A)                           | 15%       |

|                      |                                                   |            |
|----------------------|---------------------------------------------------|------------|
| ER 2nd report (year) | No reference level Degradation                    |            |
|                      | Value calculated MC tool                          | 7,970,670  |
| A                    | Median                                            | 8,256,122  |
| B                    | Upper bound 90% CI (Percentile 0.95)              | 10,661,411 |
| C                    | Lower bound 90% CI (Percentile 0.05)              | 6,206,460  |
| D                    | Half Width Confidence Interval at 90% (B – C) / 2 | 2,227,475  |
| E                    | Relative margin (D / A)                           | 27%        |

|                      |                                                   |            |
|----------------------|---------------------------------------------------|------------|
| ER 2nd report (year) | No reference level Enhancement                    |            |
|                      | Value calculated MC tool                          | 7,970,670  |
| A                    | Median                                            | 8,253,955  |
| B                    | Upper bound 90% CI (Percentile 0.95)              | 10,474,887 |
| C                    | Lower bound 90% CI (Percentile 0.05)              | 6,358,699  |
| D                    | Half Width Confidence Interval at 90% (B – C) / 2 | 2,058,094  |
| E                    | Relative margin (D / A)                           | 25%        |

|                      |                                                   |            |
|----------------------|---------------------------------------------------|------------|
| ER 2nd report (year) | No monitoring level Deforestation                 |            |
|                      | Value calculated MC tool                          | 7,970,670  |
| A                    | Median                                            | 8,328,224  |
| B                    | Upper bound 90% CI (Percentile 0.95)              | 10,860,434 |
| C                    | Lower bound 90% CI (Percentile 0.05)              | 6,124,073  |
| D                    | Half Width Confidence Interval at 90% (B – C) / 2 | 2,368,180  |
| E                    | Relative margin (D / A)                           | 28%        |

|                      |                                                   |            |
|----------------------|---------------------------------------------------|------------|
| ER 2nd report (year) | No monitoring level Degradation                   |            |
|                      | Value calculated MC tool                          | 7,970,670  |
| A                    | Median                                            | 8,310,263  |
| B                    | Upper bound 90% CI (Percentile 0.95)              | 10,489,188 |
| C                    | Lower bound 90% CI (Percentile 0.05)              | 6,407,001  |
| D                    | Half Width Confidence Interval at 90% (B – C) / 2 | 2,041,093  |
| E                    | Relative margin (D / A)                           | 25%        |

|                      |                                 |           |
|----------------------|---------------------------------|-----------|
| ER 2nd report (year) | No monitoring level Enhancement |           |
|                      | Value calculated MC tool        | 7,970,670 |

|   |                                                     |                  |
|---|-----------------------------------------------------|------------------|
| A | Median                                              | <b>8,254,680</b> |
| B | Upper bound 90% CI (Percentile 0.95)                | 10,476,074       |
| C | Lower bound 90% CI (Percentile 0.05)                | 6,357,977        |
| D | Half Width Confidence Interval at 90% $(B - C) / 2$ | 2,059,049        |
| E | Relative margin $(D / A)$                           | 25%              |

|                      |                                                     |                  |
|----------------------|-----------------------------------------------------|------------------|
| ER 2nd report (year) | No Root to shoot ratio                              |                  |
|                      | Value calculated MC tool                            | <b>7,970,670</b> |
| A                    | Median                                              | <b>8,090,091</b> |
| B                    | Upper bound 90% CI (Percentile 0.95)                | 10,201,641       |
| C                    | Lower bound 90% CI (Percentile 0.05)                | 6,220,579        |
| D                    | Half Width Confidence Interval at 90% $(B - C) / 2$ | 1,990,531        |
| E                    | Relative margin $(D / A)$                           | 25%              |

|                      |                                                     |                  |
|----------------------|-----------------------------------------------------|------------------|
| ER 2nd report (year) | No Emission factor                                  |                  |
|                      | Value calculated MC tool                            | <b>7,970,670</b> |
| A                    | Median                                              | <b>8,336,539</b> |
| B                    | Upper bound 90% CI (Percentile 0.95)                | 10,100,615       |
| C                    | Lower bound 90% CI (Percentile 0.05)                | 6,610,524        |
| D                    | Half Width Confidence Interval at 90% $(B - C) / 2$ | 1,745,046        |
| E                    | Relative margin $(D / A)$                           | 21%              |

## 6. TRANSFER OF TITLE TO ERS

### 6.1 Ability to transfer title

Madagascar has demonstrated its capacity to transfer titles to ERs. The title of ERs is the State property according to the provisions of Decree No. 2013-785 of October 22, 2013 setting the terms and conditions regarding the delegation of State forests management to public or private persons in its Article 52, which stipulates that "All woody and non-woody forest products, tangible or intangible, including forest carbons, remain the property of the State, the management of which is the exclusive responsibility of the Forestry Administration."

Decree No. 2018-500 of May 30, 2018 adopting the National REDD+ Strategy in Madagascar, specifies that the "property right on carbon" is exclusively the property of the State, through the forestry administration. The contractualization of an emission reduction payment agreement and the principle of sharing the revenues obtained, is the prerogative of the State.

The Decree No. 2021-113 on the regulation of market access also confirms this exclusivity of the State in the transfer of the ERs titles.

Please refer to the legal note: <https://www.environnement.mg/?wpdmpo=note-juridique-sur-le-transfert-des-titres#>

### 6.2 Implementation and operation of Program and Projects Data Management System

Another system called "Information System on REDD+ Initiatives and Programs" has been set up to manage the existence of projects and ensure that initiatives developed do not overlap. This system assists in the implementation and monitoring of field activities but does not generate or manage any RE Unit or title.

#### *Description of the Information System on REDD+ Program and Initiatives*

Based on the Decree on the regulation of access to the forest carbon market, Madagascar has developed its own national system called the REDD + Initiatives and Programs Information System (SIIP) <http://siip.bnc-redd.mg/>. The system was based on the REDD+ Program Environmental and Social Safeguard Information System (SIS <http://sis.bnc-redd.mg/>) that has been created since 2017. This is in line with what was set in the program's ERPD. Currently, the SIIP is operational and hosted within the BNCCREDD+. The system is available in French and is freely accessible online.

The SIIP makes it possible to collect, process, consolidate, classify and disseminate all information related to the management, monitoring and evaluation of REDD+ Programs and Initiatives.

The database consists of the following 5 main elements:

- Information on the AA-ERP with Information on 15 accredited initiatives: these elements concern the initiatives description (map, characteristics, activities, investment plan) and the approval situations of existing REDD+ initiatives with the related acts.
- Information on monitoring and evaluation of program and 15 initiatives performance carbon for the 2020 period. The ER monitoring reports 2020 period and Annex 1, 2, 3 is published there.
- Benefit sharing plan implementation: carbon benefit sharing results with all related documents. The carbon benefit utilization plans established by each initiative are also posted.
- Information on the initiatives' safeguard: the situation of the implementation of environmental and social safeguards
- Information on REDD+ related complaints: the data includes the backup activities of each initiative and the related completion reports, which are necessary for monitoring the activities. A section of the SIIP is reserved for complaints, which will be presented in a table displaying - among other things - the description

of each one of them and their status (received, processed, etc.). Each complaint is referenced according to the Region concerned and a serial number. Complaint forms, response forms and other files related to the complaint are available as attachments.

### How the SIIP works

Upstream, the system is managed by a Super Administrator (BNCCREDD+) who ensures the backup and restoration of the site.

The Administrator who is the Webmaster / Moderator (BNCCREDD+) ensures the content total management: addition, deletion, modification, publication; as well as the users and interfaces management.

The Operators who are the BNCCREDD+ managers and the RRCs ensure the content entry (addition, deletion and modification according to privileges) and the final data integration.

The initiatives and the RRCs are the authenticated users who make conditional additions of elements (without publication, the additions await the validation of the administrators), conditional modification of information: according to privileges and conditional consultation of specific information.

Downstream, there is the public or visitors. They can consult and download information published in the SIIP.

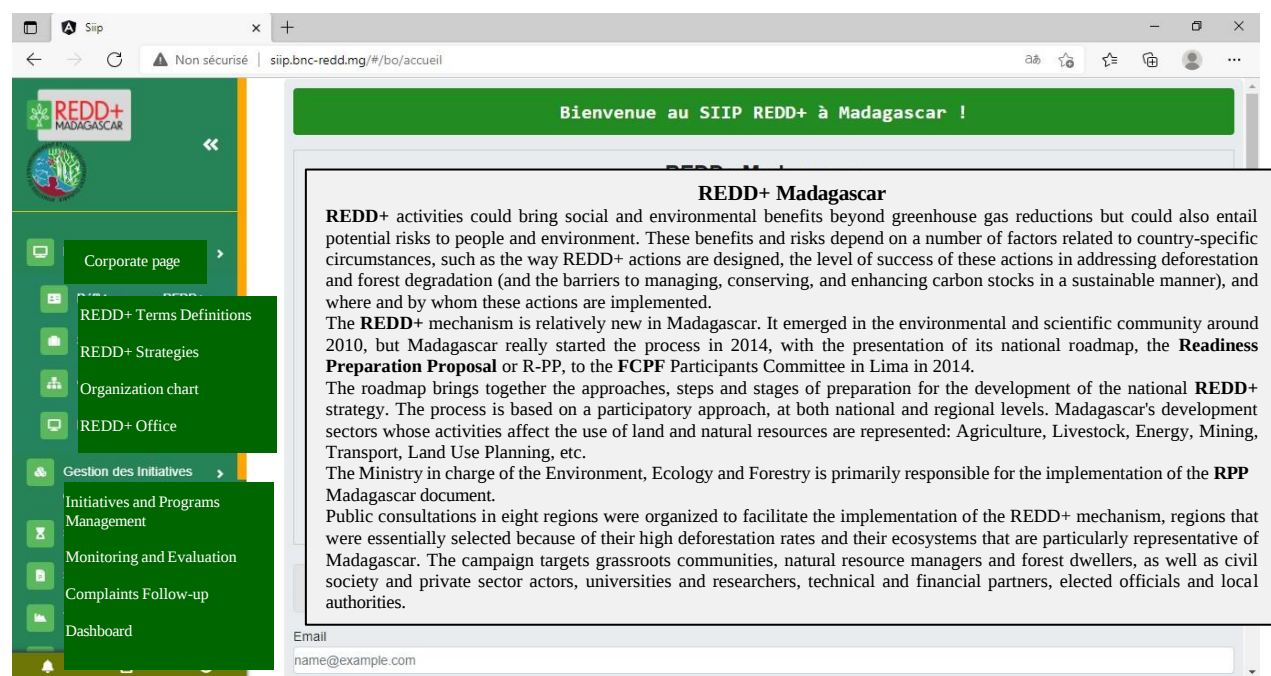


Figure : REDD+ Initiatives and Program Information System Interface

## 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 and 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

The terms of the payment contract for the Atiala Atsinanana Program provide for an 85/15 split on volume during a reporting period, meaning that 85% of the ERs generated under the ER program during a reporting period must be transferred to the trustee as contract ER, and the remaining 15% of the ERs generated can be used by the country for other purposes. However, for the 2021-2022 reporting period, Madagascar does not plan to sell any volume of ER from the Program to other buyers and intends to transfer the 100% to FCPF.

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 2021-2022 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.

|    |                                                                                                                                                                          |                                                    |  |  |   |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|--|--|---|
|    |                                                                                                                                                                          |                                                    |  |  |   |
| A. | ER Program Reference level for this Reporting Period (tCO <sub>2</sub> -e)                                                                                               | from section 4.1                                   |  |  |   |
|    |                                                                                                                                                                          |                                                    |  |  |   |
| B. | ER Program Reference level for all previous Reporting Periods in the ERPA (tCO <sub>2</sub> -e).                                                                         | from section 4.1 of previous ER Monitoring Reports |  |  | + |
|    |                                                                                                                                                                          |                                                    |  |  |   |
| C. | Cumulative Reference Level Emissions for all Reporting Periods [A + B]                                                                                                   |                                                    |  |  |   |
|    |                                                                                                                                                                          |                                                    |  |  |   |
| D. | Estimation of emissions by sources and removals by sinks for this Reporting Period (tCO <sub>2</sub> -e)                                                                 | from section 4.2                                   |  |  |   |
|    |                                                                                                                                                                          |                                                    |  |  |   |
| E. | Estimation of emissions by sources and removals by sinks for all previous Reporting Periods in the ERPA (tCO <sub>2</sub> -e)                                            | From 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] |                                                    |  |  | — |
|    |                                                                                                                                                                          |                                                    |  |  |   |
| 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]     |                                                    |  |  |   |
|    |                                                                                                                                                                          |                                                    |  |  |   |
| 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                                                                                                                                      |                                                  |  |  |  |
|                                                                             |                                                                                                                                                                                   |                                                  |  |  |  |
| 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 ] |                                                  |  |  |  |
|                                                                             |                                                                                                                                                                                   |                                                  |  |  |  |
| 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]                                  |                                                  |  |  |  |
|                                                                             |                                                                                                                                                                                   |                                                  |  |  |  |

### 7.3 Quantification of pooled reversal buffer replenishments

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

|    |                                                                                                                                                                                                                                                                                                        |                                                    |   |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|---|
| A. | Emission Reductions during the Reporting period (tCO <sub>2</sub> -e)                                                                                                                                                                                                                                  | from section 4.3                                   |   |
| B. | If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)                                                                                                                            |                                                    |   |
| C. | Number of Emission Reductions estimated using measurement approaches (A-B)                                                                                                                                                                                                                             |                                                    | - |
| D. | Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested                                                                                                                                                                                                           | from section 6.1                                   |   |
| E. | ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes | from section 6.4                                   |   |
| F. | Cumulative Pooled Reversal Buffer cancellations (as an aggregate since the Crediting Period Start Date)                                                                                                                                                                                                | from previous ER monitoring reports section 7.2, O |   |
| G. | 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     |   |
| H. | Proportion of cumulative Pooled Reversal Buffer cancellations/cumulative Pooled Reversal Buffer contributions [F / G]                                                                                                                                                                                  |                                                    |   |
| I. | Year of the Crediting Period where the latest reversal took place (e.g., 1,2,3...)                                                                                                                                                                                                                     | from previous ER monitoring reports                |   |

|                                                                                                              |                                                                                                                                                                                                                                                                                                                                                          |                                                        |  |
|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--|
| J.                                                                                                           | Cumulative Pooled Reversal Buffer cancellations (as an aggregate since the Crediting Period Start Date)                                                                                                                                                                                                                                                  | from previous ER monitoring reports and section 7.2, O |  |
| K.                                                                                                           | Cumulative previous Pooled Reversal Buffer replenishments (as an aggregate since the Crediting Period Start Date)                                                                                                                                                                                                                                        | from previous ER monitoring reports, section 7.3 Q     |  |
| L.                                                                                                           | Proportion of cumulative previous Pooled Reversal Buffer replenishments/cumulative Pooled Reversal Buffer cancellations $[K / J]$                                                                                                                                                                                                                        |                                                        |  |
| Complete either a), b) or c) below, depending on the situation, to estimate the amount of the replenishment: |                                                                                                                                                                                                                                                                                                                                                          |                                                        |  |
| M.                                                                                                           | a) If $L < 0.5$ , Pooled Buffer replenishments equal $(B+C)*D-E$ , noting that the replenishment should not be larger than the value of J-K                                                                                                                                                                                                              |                                                        |  |
| N.                                                                                                           | b) If $L > 0.5$ , indicate the percentage of ERs generated that you wish to convert to Total ERs [0 to 0.3]                                                                                                                                                                                                                                              |                                                        |  |
| O.                                                                                                           | Pooled Buffer replenishments $[(B+C)*(D-E)*N]$ , noting that the replenishment should not be larger than the absolute value of J-K                                                                                                                                                                                                                       |                                                        |  |
| P.                                                                                                           | c) If the latest reversal has taken place from the third year of the Crediting Period on (as per L above) or if it represents more than 50% of the current net Pooled Reversal Buffer contributions (as per H above), Pooled Buffer replenishments equal $(B+C)*D-E$ , noting that the replenishment should not be larger than the absolute value of J-K |                                                        |  |
| Q.                                                                                                           | Total Pooled Reversal Buffer replenishment for the reporting period                                                                                                                                                                                                                                                                                      |                                                        |  |

## 7.4 Reversal risk assessment

The reversal risk assessment using the Buffer Guidelines has not changed since the preparation of the ERP-AA final ERPD. Therefore, no risk other than the 4 listed in the Buffer Guidelines has been identified.

The program lasts for 5 years and actually, the largest payment of ERs from the program comes at the end of the third period, i.e. beyond the duration of the ERPA. These funds are intended to sustain the activities carried out under the program, including those that strengthen community livelihoods and reduce the risks of reversal.

Indeed, the Program's benefit-sharing plan provides for the use of carbon revenues to sustain and increase the Program's activities both during the Program and beyond. Nevertheless, during the period of the report, any payment hasn't come.

It is also important to note that the governance of the REDD+ mechanism and the Program was designed purposely to enhance existing structures (public and administrative structures), mobilizing local actors (based communities and delegated managers) and ensuring that at the end of the Program, all structures and capacities remain and continue to operate.

The assessment of natural and anthropogenic risks of reversals that was conducted following the FCPF Buffer Guidelines and the four main risk factors described:

- Lack of broad and sustained stakeholder support
- Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination
- Lack of long term effectiveness in addressing underlying drivers
- Exposure and vulnerability to natural disturbances

More generally, the focus on watersheds is designed to be inclusive of populations in contiguous communities thus limiting the most immediate risk of incursions from neighboring populations. These natural geographic/geologic target groups (watersheds) provide a degree of natural impediment to largescale population influxes, and also enable program design that is tailored to each program area, with the identified activities.

**Table 8 : Reversal risk assessment**

| Risk Factor                                            | Risk indicators                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Default Reversal Risk Set-Aside Percentage | Discount      | Resulting reversal risk set-aside percentage |
|--------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|---------------|----------------------------------------------|
| <b>Default risk</b>                                    | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 10%                                        | N/A           | 10%                                          |
| <b>Lack of broad and sustained stakeholder support</b> | <p>The REDD+ mechanism's implementation highly depends on the support of the stakeholders at all levels, such as government, initiative and communities. To ensure a sustained support to the ERP, Madagascar has elaborated and implemented frameworks documents and has instituted official structure.</p> <p>From 2021, 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 following consultations and validations with stakeholders at the national, regional and commune</p> | 10%                                        | Low risk: 10% | 0%                                           |

|                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |            |                       |            |
|--------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-----------------------|------------|
|                                                                                                  | <p>level, as well as the five initiative promoters, platforms, national and regional authorities and communities. Funding contracts and agreements will also be drawn up between national REDD+ coordination and initiative managers in the ERPAA to reassure their support and engagement in the REDD+ program.</p> <p>To promote coordination and support for stakeholders at local level, structures have been set up to ensure the operationalization of the REDD+ mechanism, including REDD+ regional Coordination (RRC), local governance within each initiative and complaints local committees in the program's communes and fokontany.</p> <p>In addition, capacity building for stakeholders has been carried out at all levels from the program's preparation to its implementation.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |            |                       |            |
| <b>Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination</b> | <p>Are there key institutions with experiences in implementing REDD+ project / programs?</p> <p>The success of the REDD+ mechanism in Madagascar hinges on the establishment of an appropriate political, and institutional framework to ensure governance consistent with the sectoral policies deforestation and forest degradation.</p> <p>The Program has the advantage of integrating WCS and CI that implemented REDD+ pilot projects in Madagascar. Indeed, they already have convincing experience in the implementation of REDD+ and benefit sharing process.</p> <p>Moreover, as far as protected areas are concerned, all the five initiative promoters have 5 years' experience or more about conservation, sustainable management and stock enhancement activities.</p> <p>Is there a lack of cross sectorial coordination necessary for REDD+ efficiency?</p> <p>The</p> <p>The REDD+ mechanism's governance and institutional arrangements is developed in the national REDD+ strategy in order to empower coordination across sectors. There is vertical coordination at the national, regional and local level to ensure the REDD+ implementation.</p> <p>With regard to the concrete implementation of the Program, the MEF is a signatory to the ERPA in the same way as the MEDD. Its commitment is established both by the the ERPA and by the CAS operations manual, which sets out a clear interplay and sharing of</p> | <b>10%</b> | <i>High risk : 0%</i> | <i>10%</i> |

|                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |                       |           |
|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------|-----------|
|                                                                         | <p>responsibilities within the management of the REDD+ payments and the BSP implementation.</p> <p>In addition, capacity building for stakeholders has been carried out at all levels in the five regions from the program's preparation to its implementation.</p> <p>The lack of intersectoral coordination that is one of the indirect drivers of deforestation will be addressed by the strategic orientation N°1 of the REDD+ national strategy. It aims to stand an effective governance by the improvement of political, legal, institutional and financial framework.</p> <p>However, given that the mechanisms and systems put in place are new (in particular the financial mechanism and the regulations in force), it is recognized that a period of readjustment and running-in is necessary. The BNCCREDD+ will need to provide ongoing capacity-building and technical support in this respect. In the meantime, a slight risk may remain.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |                       |           |
| <b>Lack of long-term effectiveness in addressing underlying drivers</b> | <p><i>Is the program able to link REDD+ to economic activities and development?</i></p> <p>1/ In the context of Madagascar, the main risks of ineffectiveness within the area of the project are associated with the practice of slash and burn agriculture ("Tavy") and uncontrolled extraction of wood energy. Both practices are largely associated with poverty of rural households in Madagascar, a situation exacerbated during periods where households are facing food emergencies. These risks are of anthropogenic origin.</p> <p><u>Mitigation measures:</u> The strategic orientation No 4 in the REDD+ National strategy is designed particularly to address these practices. The aim is to sustainably transform the way to use forest products by agricultural and vulnerable households: it concerns (i) the development of infrastructures (construction of hydro-agricultural dam), (ii) the development and extension of food crops and income-generating activities and (iii) the propagation, intensification and promotion of cash crops and agroforestry. That are dedicated to improve the agricultural practices and the access to market in order to increase productivity and at the same time increase revenues of local populations, allowing them to progressively reduce their dependency on subsistence agriculture.</p> <p>2/ 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</p> | <b>5%</b> | <i>High Risk : 0%</i> | <b>5%</b> |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |  |  |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
|  | <p>the local economy. During the reference period, these commodities had a two-faceted impact on deforestation: not only, it can incentivize local populations to cut forest parcels in order to implement production; but, such production is also implemented on fallow land or secondary forest, allowing their maturation and increasing carbon stocks on land with relatively low carbon content.</p> <p><u>Mitigation measure:</u> The program will implement measures to reduce the risk that such commodities trigger deforestation and are systematically produced under agroforestry systems, thus participating in carbon stock enhancement when settled on fallow land or secondary forest. Most of the protected areas are already fostering such practices within their surrounding agriculture belt, with positive experiences and feedbacks.</p> <p>3/ 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. This context is particularly witnessed in projects/programs of relatively short lifespan.</p> <p><u>Mitigation measures:</u> The ER Program design focuses on the development of activities that can be inclusive of incoming populations through the promotion of “no-land” activities, income-generating activities that are not dependent on land ownership, and will limit anarchic land grabs that may be associated with these practices. “No-land” activities are designed to strengthen the value chains that will reduce pressures on forest degradation directly and also indirectly through decreasing the demand for extensive land practices. These types of activities will also be supported by the safeguard framework implementation. The benefit sharing plan also sets a part of the revenue to expand the areas of activities and to increase the target population, in order to cover the entire area of the program.</p> <p>Is relevant legal and regulatory environment conducive to REDD+ objectives?</p> <p>The government of Madagascar has taken several legal and regulatory steps to integrate REDD+ into the legal framework for environment and climate change mitigation in the country. The Decree No. 2021-1113 of October 20, 2021 on the regulation of access to the forest carbon market (DRMCF) clarifies key legal and institutional process for the REDD+ implementation.</p> |  |  |  |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|

|                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                         |           |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------------------------|-----------|
|                                                           | Mitigation measures are already in place for addressing underlying drivers and that will be planned in the initiatives' utilization plan. So, the risk will be prevented and mitigated when the revenue would be issued for their implementation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |                         |           |
| <b>Exposure and vulnerability to natural disturbances</b> | <p><i>Risks due to natural forest fire.</i></p> <p>The project area is a humid rainforest habitat. Natural fires in Madagascar are mostly limited to savannah habitats. There is no reference or available information of natural fire resulting in large-scale deforestation in the humid forest of Madagascar. All fires are, according to literature, due to human activities in this part of the country. Cyclone damage can enable fire propagation but the origins of fires are largely anthropogenic.</p> <p>Anyway, Madagascar has Ordinance 60-127 on clearing land and vegetation fires, which is currently in force face to the event of fires. Protected areas also have their own fire-fighting strategies.</p> <p><i>Risks due to pests and disease</i></p> <p>No major pest or disease outbreaks leading to die-off of forest have been recorded in rainforests in Madagascar. Large-scale tree pest and disease outbreaks are extremely rare in tropical natural forests due to the high diversity of tree species and low densities that are typical (Nair, 2007).</p> <p>The text in force governing the phyto pathological diseases is the Ordinance 86-013 on phytosanitary legislation in Madagascar. The Ministry in charge of forests and the Ministry in charge of agriculture plan to set up a legal framework to work on appropriate preventive and curative phyto pathological measures, specific to forest species.</p> <p><i>Risks of extreme climate events that could contribute to deforestation.</i></p> <p>The only extreme climate events recorded on the east coast of Madagascar are cyclones. Nevertheless, at the period of report, official data on cyclone's impacts that hit the east coast of Madagascar have not shown significant impacts on forest's loss.</p> <p>However, to strengthen the resistance of forests to cyclones, the National Program for Adaptation to Climate Change encourages the reforestation of indigenous species that have deeper roots and are more resistant to extreme winds.</p> <p>Prevention and mitigation measures related to the risks due to natural disturbances are eligible under strategic orientation N°3 of the national REDD+</p> | <b>5%</b> | <i>medium risk : 2%</i> | <b>3%</b> |

|   |                                                                                      |                                                                          |     |  |
|---|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----|--|
|   | strategy (promoting the sustainable management and development of forest resources). |                                                                          |     |  |
| . |                                                                                      | 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

Table 9 : ERs available for transfer to the Carbon Fund

|    |                                                                                                                                                                                                                                                                                                        |                         |            |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------|
| A. | Emission Reductions during the Reporting period (tCO <sub>2</sub> -e)                                                                                                                                                                                                                                  | <i>from section 4.3</i> | 15,941,996 |
| B. | If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)                                                                                                                            |                         | 0          |
| C. | Number of Emission Reductions estimated using measurement approaches (A-B)                                                                                                                                                                                                                             |                         | 15,941,996 |
| D. | Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested                                                                                                                                                                                                           | <i>from section 6.1</i> | 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 | <i>from section 6.4</i> | 0          |

|    |                                                                                                                                                                                                |                         |            |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------|
|    | If applicable, any buffer replenishments                                                                                                                                                       | <i>section 7.3 P</i>    |            |
| F. | Total ERs [(B+C)*D-E] minus, if applicable, any replenishments as per section 7.3, Q                                                                                                           |                         | 15,941,996 |
| G. | Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period                                  | <i>from section 5.2</i> | 4%         |
| H. | Quantity of ERs to be allocated to the Uncertainty Reversal Buffer $(0.15*B/A*F)+(G*C/A*F)$                                                                                                    |                         | 637,679    |
| I. | Total reversal risk set-aside percentage applied to the ER program                                                                                                                             | <i>from section 7.4</i> | 28%        |
| J. | Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*I                                                                                                                          |                         | 4,285,208  |
| K. | Number of FCPF ERs (F- H – J)                                                                                                                                                                  |                         | 11,019,109 |
| L. | Percentage of Emission reductions from enhanced removals from afforestation/reforestation as a percentage of the total removals [Optional if the country wishes to generate enhanced removals] | <i>From section 4.3</i> | 0          |
| M  | Number of FCPF ERs from enhanced removals from afforestation/reforestation $(L * K)$ [Optional if the country wishes to generate enhanced removals]                                            |                         | 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>3.1</b> | July 2024     | <ul style="list-style-type: none"> <li>The frontpage table and Sections 7 and 8 have been revised to reflect the provisions of the Buffer Guidelines version 4.2, namely: <ul style="list-style-type: none"> <li>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;</li> <li>The merge of Reversal Buffers and the Pooled Reversal Buffer; and</li> <li>The recognition that not only the ERs transferred to the Carbon Fund may suffer reversals.</li> </ul> </li> <li>Section 2.2 has been included to allow ER Programs report any updates to the validated monitoring plan.</li> </ul> |
| <b>3</b>   | February 2024 | Version approved virtually by Carbon Fund Participants. Changes made: <ul style="list-style-type: none"> <li>Sections 4.3 and section 8 were adjusted to be able to report ERs from removals separately</li> <li>Annex 5 was included to provide a detailed report on the application of the Reversal Risk Assessment Tool</li> </ul>                                                                                                                                                                                                                                                                                                                                                 |
| <b>2.5</b> | May 2023      | <ul style="list-style-type: none"> <li>Section 4.3 has been revised to provide guidance on how to consider non-performance or reversals from previous periods</li> <li>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</li> </ul>                                                                                                                                                                                                                                                                                                                                |
| <b>2.4</b> | May 2022      | <ul style="list-style-type: none"> <li>Page 1 and section 8 have been adjusted to reflect the definition of Total ERs</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>2.3</b> | December 2021 | <ul style="list-style-type: none"> <li>Section 5.2 was adjusted to allow the reporting of the uncertainty estimates for both the reporting period and the crediting period.</li> <li>Section 8 has been adjusted to clarify that countries can also report ERs jointly and not only in separate calendar years.</li> </ul>                                                                                                                                                                                                                                                                                                                                                            |
| <b>2.2</b> | August 2021   | <ul style="list-style-type: none"> <li>Cross-references have been corrected</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

|            |               |                                                                                                                                                                                                                                                                                                                                                 |
|------------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|            |               | <ul style="list-style-type: none"> <li>Information about the start date of the crediting period has been requested in annex 4.</li> </ul>                                                                                                                                                                                                       |
| <b>2.1</b> | November 2020 | Aspects on uncertainty analysis were revised based on the guidelines on uncertainty analysis.                                                                                                                                                                                                                                                   |
| <b>2</b>   | June 2020     | <p>Version approved virtually by Carbon Fund Participants. Changes made:</p> <ul style="list-style-type: none"> <li>Update to consider the changes made to the Methodological Framework (Version 3.0) and Buffer Guidelines (Version 2.0)</li> <li>Update to consider the changes made to the Validation and Verification Guidelines</li> </ul> |
| <b>1</b>   | January 2019  | The initial version approved by Carbon Fund Participants during a three-week non-objection period.                                                                                                                                                                                                                                              |