# MAKIRA FOREST PROTECTED AREA PROJECT

## MONITORING REPORT 2010 TO 2013

Document Prepared By
Wildlife Conservation Society Madagascar

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<th>Project Title</th>
<th>The Makira Forest Protected Area Project in Madagascar.</th>
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1 PROJECT DETAILS

1.1 Summary Description of Project

The Makira forest lies within the Antongil Bay landscape of North-eastern Madagascar and represent one of the largest expanses of humid forest left in the biologically rich Eastern Rainforest Biome of Madagascar. The forests of Makira are a key intact biodiversity stronghold and a vital bridge maintaining long-term connectivity and altitudinal gradient protection across protected areas in the north eastern region: Anjanaharibe-Sud Special Reserve and Marojejy National Park in the North; Masoala National Park in the East; and Mananara-Nord National Park and the special reserves of Marotandrano and Ambatovaky in the South.

Interest in managing the Makira forest bloc dates back to 1958, when eight forests parcels totalling approximately 221,410 hectares of the forest were established as “Classified Forest” by the Ministry of Water and Forests. These are forests identified to have some importance in terms of ecosystems and biological diversity and therefore afforded a “classification” by the government. However, weak enforcement of legislation and regulations due to limited means and capacities of the State combined with pressure from an expanding human population resulted in increased deforestation and fragmentation, with an estimated forest loss of 1,500 hectares per year.

The main driver of deforestation in the Makira forest is a form of slash and burn agriculture, known as tavy, that is used to cultivate rain-fed rice rather than irrigated rice. Used principally for subsistence needs, tavy is typically practiced in upland forested areas and deforested lands are usually abandoned after one or two years of production and farmers move to another place. Other deforestation drivers are clearing for pastures, small scale or illegal mining and illegal small-scale logging. Underlying these activities are factors such as open access to forest resources, rapid population growth, poverty and insecurity that are driving unsustainable resource use.

In 2001, during an International Symposium on sustainable financing for Protected Areas, carbon financing was identified as one instrument that could be used to financially support environmental action. As a result of the symposium, it was then recommended to initiate a pilot project to test carbon-financing mechanisms. As a follow up to this symposium, International Resources Group (IRG), through a USAID-funded project, and the Wildlife Conservation Society (WCS) have been working with Madagascar’s Ministry of Water and Forests (MEF) to develop carbon financing options to enhance conservation of the Makira forest in north-eastern Madagascar.

In 2001, the Madagascar Ministry of Water and Forests (MEF), in collaboration with the Wildlife Conservation Society (WCS), launched a program to create the Makira Forest Protected Area and to finance it at least partially through carbon markets. Makira Forest Protected Area Project, hereafter referred to as the Makira Project, protects one of the largest remaining contiguous tracts of low and mid-altitude rainforest in eastern Madagascar—ecologically and biologically important because of the high biodiversity value and large numbers of plants and animals found nowhere else in the world. In order to reduce emissions from deforestation and forest degradation (REDD) in an efficient and sustainable manner, the project has adopted a multifaceted and multidisciplinary approach to address the very real human threats acting upon the region’s forests, while at the same time considering the development needs of local populations and integrating them into the management of the protected area. The main activities include:

- The creation and sustainable management of the Makira new protected area, including research and biodiversity monitoring.
- The development of contracts to transfer forest resources management (Transfert de Gestion or GCF) to local communities in the protection zone surrounding the protected area, and activities that strengthen local institutions including land use planning (zoning), community socio-organization and capacity-building.
MONITORING REPORT: VCS Version 3

- Rural development and alternative livelihood creation for these adjacent communities, including diversification of sources of income, improved agricultural techniques, infrastructure development, micro-finance and ecotourism.
- Communication and Environmental Education, including health-related activities.

WCS has conducted consultations since the beginning of the Makira Protected Area project with all stakeholders groups, from the national to the local level, concerning all aspects of project implementation. Special attention was given to the limits and zoning of the protected area, the management measures, identification of potential impacts and possible compensation measures including supports to livelihoods (cf. table 1).

After the temporary creation of the protected area in December 2005, WCS began to explore how to monetize the Park’s ecosystem services, particularly through carbon offset sales. Thus in June 2008, the Government of Madagascar signed an agreement with the Makira Carbon Company (MCC), a not-for-profit, private company incorporated by WCS in Delaware, USA and wholly-owned subsidiary of WCS, to market the estimated 34 million tons of carbon generated through avoided deforestation in Makira, over the next 30 years. The revenues from carbon sales, generated through avoided deforestation of the Makira forests will be used to finance its long-term conservation, improve community land stewardship and governance and support sustainable livelihood practices leading to improved household welfare. In order to achieve its climate change mitigation goals, the Makira Forest Project will reduce deforestation rates in the new protected area to below 100 ha per year and create the incentives necessary to maintain those low rates in the future.

The Makira Protected Area Project is designed to not only include adjacent communities but to empower them to manage their resources sustainably and participate in the co-management of the protected area. First, as part of the zoning process, WCS worked to organize communities into community based forest management sites, where management responsibility has been officially devolved to communities living along the perimeter of the forest through a contract between the ministry of forests and elected communal forest authorities. Ownership remains with the central government, but communities have the rights and responsibility to manage their natural resources in forest groups known as COBAs.

In addition to this devolution of resource rights, a co-management structure for the protected area was developed based on consultations so that communities can participate in park decisions. The overall co-management structure is made up of three committees (steering, management and advisory) and includes government, community, and NGO representatives. Representatives of the Federation of COBAs sit on the Makira PA steering committee. This management structure helps address leakage by creating a structure that includes and gives voice to the main deforestation agents.

1.2 Sectoral Scope and Project Type

As per the VCS program definitions, the Makira project falls under the VCS sectoral scope 14 Agriculture, Forestry and Other Land Use (AFOLU), under the project category Reduced Emissions from Deforestation and forest Degradation (REDD). The project conforms with the VCS REDD category of Avoiding Unplanned Frontier Deforestation and Degradation (AUFDD) and falls under the frontier deforestation configuration, because at project start major parts of the Makira forests are remote and access is expected to improve and lead to increased encroachment by local populations, as described in section 4.2.9, sub-section 2b paragraph i) of the VCS AFOLU requirements (v. 3.2).
Figure 1: General situation of the Makira Protected area and Project Zone
1.3 Project Proponent

The Wildlife Conservation Society (WCS) is the proponent of the Makira REDD project. Founded in 1895, WCS is an internationally recognized organization dedicated to preserving the Earth’s wildlife and wild places. WCS currently oversees a portfolio of more than 500 conservation projects in 60 countries in Asia, Africa, Latin America, and North America. WCS works with national governments, universities, non-governmental organizations (NGOs) and dedicated individuals to increase understanding and awareness of the importance of wildlife though the establishment and strengthening of protected areas. More recently, WCS as engaged in the development of its carbon for conservation initiative.

Currently, WCS is working with communities and governments in 18 landscapes and 14 countries to develop sub-national REDD+ demonstration projects and support the development of national REDD strategies. WCS believes that work at sub-national and national levels should be linked in such a way that national REDD strategies are informed by on-the-ground experience obtained through demonstration projects. WCS only works on sub-national REDD+ demonstration projects in landscapes where it has or plans to have a long-term presence. This long-term presence is a prerequisite to success in order to understand the drivers of deforestation and implement activities that reduce deforestation effectively and ensure permanence with community’s consent and participation.

Together the WCS portfolio of projects demonstrates how to develop REDD in varied institutional, socio-economic and ecological environments. By working with government, WCS will work to develop national REDD strategies sensitive to local conditions that effectively stem emissions from deforestation and degradation.

The Makira Project’s technical team includes 21 technical experts with relevant educational, training and professional backgrounds. Since 2003, WCS has successfully managed the Makira Project and its interventions led to the temporary creation of the Makira protected area in December 2005 and to the definitive creation in July 2012. In parallel, WCS supported the creation of 46 management transfers in the protection zone surrounding the protected area. The various contracts and agreements WCS concluded since 2003 with the national government and local communities also demonstrates the commitment of WCS to support sustainable management and conservation of the Makira forest, leading to the delegation of management of the Makira protected area to WCS by Ministerial order in December 2011 and the signature of a management delegation contract in June 2011. These successes demonstrates the long-term engagement and technical capacities of WCS and therefore justify a low risk associated with the implementation and permanence of the Makira Project.

In Madagascar, WCS is represented by Alison Clausen (WCS Madagascar Country Program Director). WCS is the developer and implementing institution of the project in the field, including the management of the protected area. In the United States, where WCS is incorporated, Todd Stevens is the main representative.

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1.4 Other Entities Involved in the Project

Besides WCS Madagascar, the following entities are involved in the Makira Project:

- **The State of Madagascar through the Ministry in charge of the Environment and Forests (MEF)** as the supervision authority of the project. In addition, the State of Madagascar is the owner of all forests in the Makira protected area and thus considered the owner of all emission offsets generated by the Makira project (cf. section 1.12.1) and the only entity habilitated to sell these carbon credits.

- **Local communities**, including various local authorities and particularly the COBAs associations, are partnering with WCS in the co-management of the Makira Protected area together with its protection zone. As set out in the agreement concluded between the State and MCC (see below), local communities will be the main beneficiaries from revenues generated by sales of carbon credits, although the project does not account for emission reductions generated in the community managed forests in the protection zone of the Makira protected area. These funds will be invested mainly into deforestation reducing activities such as improvement of agricultural productivity, development of alternative revenue sources and support to rural development in general (education, health, etc.).

- **The Makira Carbon Company (MCC)**, a non-profit carbon offset organization established by WCS, has the exclusive right to market, distribute, promote, advertise or otherwise deal with the allocated Makira emission offsets subject to consultation as set forth in an agreement signed with the MEF (cf. section 1.12.1 and annex 3).

- A “Designated Foundation” will be in charge of distributing the net proceeds held in escrow, from sales of Allocated Makira Emission Offsets. The funds will be distributed in accordance with well-defined allocations as described in the agreement between MCC and MEF (cf. section 1.12.1). The details on how exactly these funds are to be distributed to the beneficiaries (local communities, forest administration and delegated manager of the Makira protected area) will be set out in an agreement between the foundation, the State and the delegated manager of the Makira protected area and supervised by a steering committee composed by all stakeholders, including local community representatives.

1.5 Project Start Date

Under the VCS, the project start date for an AFOLU project is “the date on which activities that lead to the generation of GHG emission reductions or removals are implemented” (VCS AFOLU Requirements 3.2.1). In the case of the Makira project the following activities, agreements and interventions have to be considered (cf. figure 2):

- In 2001, the Madagascar Ministry of Water and Forests (MEF), in collaboration with the Wildlife Conservation Society (WCS), launched a program to create the Makira Forest Protected Area and to finance its management, at least partially, through carbon markets.

- Detailed biological and ecological inventories and surveys have been conducted in the Makira forests starting in late 2002. Detailed results from these studies and inventories are presented in the biodiversity sections of the Makira CCBA project description submitted in parallel with the Makira VCS PD.

- In 2003 a convention was signed between WCS and the MEF recognizing WCS as implementing organisation of the Makira conservation site project. This gave WCS responsibility for setting up the first project management structures in the Makira area and consequently lead to a substantially increase of its presence in the area in order to ensure management of the project, conduction of further ecological and socio-economic field studies and support local communities in developing management transfers, co-management structures for the future Makira protected area and rural development and alternative revenue activities. This
progressively extended field presence of WCS, including animators living in the villages inside
the future protected area (Controlled occupation zones ZOC) and its protection zone, certainly
had a positive effect on forest conservation in the area.

• In 2004 WCS launched socio-economic studies and consultations with local communities on the
creation of management transfers in the planned protection zone of the future Makira protected
area. The first two transfer contracts for the Andapa zone were signed between communities
and MEF in November and the first eight contracts in the Maroantsetra zone in December 2004
and in parallel WCS supported local communities in strengthening their capacities regarding
sustainable management and monitoring of natural resources and developing co-management
structures for the future protected area. As described in more detail in the Makira PD,
management transfer contracts include management plans and dina, containing rules and
procedures (control, monitoring, etc.) regarding conservation and sustainable use of forest
resources and the signature of the management transfer contracts between local communities
and the state (represented by the regional forest service) can therefore be considered as start
of the implementation of forest protection activities leading to first emission reductions in the
future protected area and its protection zone.

• At the end of 2004 WCS, in close collaboration with Winrock, completed a feasibility study for a
REDD project in the Makira forests which provided a first estimation of the GHG reduction
potential of the project. This provided a first basis for the credit pre-sales described below.

• The above-mentioned feasibility study lead to the sale of 40,000 t of pre-certified emission
reductions through December 2006 through the Conservation International Centre for
Environmental Leadership (CI CELB). The proceeds from this sale contributed to the further
development of the Makira project as set forth in an agreement between the MEF and
Conservation International.

• In early 2005 consultations with local communities on the delimitation and final creation of the
Makira protected area started and lead to the temporary creation in December 2005.

• Management transfers are not possible inside the future protected area, but WCS started in
early 2005 working with populations living inside the Makira on delimitating and developing
management plans for the future zones of controlled occupation (ZOC) and zones of controlled
use (ZUC). Rules and procedures contained in these management plans are similar to the ones
mentioned above for the management transfers. Although these plans are not formalized by a
contract between the forest administration and the local communities they have been formalized
locally in 2006 and can be expected to have a similar effect on conservation of forest resources
as the transfers and can therefore also be considered having triggered further emission
reductions in the future project area.

• In early 2005 consultations with local communities on the delimitation and final creation of the
Makira protected area started. They were based on the ecological and socio-economic studies
conducted earlier and lead ultimately to the temporary creation by ministerial decree in
December 2005.

• Additional pre-sales of 114,329 t of pre-certified emission reductions concluding in December
31, 2011 again through the Conservation International Centre for Environmental Leadership (CI
CELB). The proceeds from this sale contributed to the further development of the Makira project
as set forth in a second agreement between the MEF and Conservation International.

The main activities leading to emissions reductions and/or removals are the creation of the new
Makira Protected area prohibiting deforestation and forest degradation in the project area, the setting
up of efficient management structures including local communities and the implementation of control
and monitoring mechanisms. Figure 2 above shows that although the Makira protected area was
created temporarily only in December 2005, consultations with local communities on delimitation and
co-management of the new protected area and preparation of the management transfers started as early as 2004 and resulted in the creation of the first ten management transfers in the protection zone in late 2004. It was also in December 2004 that the first carbon-financing programme (December 2004 to March 2006) based on pre-certified emission reduction credits was signed with Conservation International and the Government of Madagascar.

Activities and investments occurring before January 2005 in and around the project area have been focused on analysing the general ecological and socio-economic conditions in the area as well as the potential for reducing emissions from deforestation and forest degradation and are therefore not considered having directly triggered emission reductions and/or removals in the project area of the Makira project.

It is thus considered that the implementation of the Makira protection plans in the sense of the VCS AFOLU requirements mentioned above became effective in early 2005 and consequently January 1st 2005 has been selected as the project start date.

Figure 2: Makira Project timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>2002</td>
<td>Biological &amp; ecological inventories completed and used to validate the biological importance of Makira forests</td>
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<tr>
<td>2003</td>
<td>Project development convention WCS-MEF, which formalized the process to establish the Makira Protected Area</td>
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<tr>
<td>2004</td>
<td>WCS begins the process of establishing community forest mgmt transfer sites, with the 1st 10 sites created</td>
</tr>
<tr>
<td>2005</td>
<td>January 1, 2005 Makira Carbon Project Start Date</td>
</tr>
<tr>
<td>2006</td>
<td>December 31, 2005 Makira is issued temporary protected Area Status</td>
</tr>
<tr>
<td>2007</td>
<td>June 19, 2012 Makira Natural Park is officially created by decree 2012-641</td>
</tr>
<tr>
<td>2008</td>
<td>REDD Feasibility Study conducted</td>
</tr>
<tr>
<td>2009</td>
<td>VCS PDD Validation and 2005-2009 Verification</td>
</tr>
<tr>
<td>2010</td>
<td>1st pre-certified carbon credits are sold</td>
</tr>
<tr>
<td>2011</td>
<td>2nd pre-certified carbon credits are sold</td>
</tr>
<tr>
<td>2012</td>
<td>1st certified VCUs are sold</td>
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<tr>
<td>2013</td>
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Major Events during the current monitoring period are the following:

- On 19 June 2012, the Government approved the definitive creation of the Makira protected area (cf. http://www.newsmada.com/communique-conseil-de-gouvernement-du-19-juin-2012-mahazoarivo/). Decree n° 2012 – 641 has been signed by the different concerned Ministries in late 2012 and has been published in the official journal in December of the same year. A copy of the decree is provided in annex 5.

- On 28 September 2012, the Rainforest Alliance validates that the Makira Forest Protected Area Project is in conformance with the Verified Carbon Standard (VCS) Version 3 under Validation Registration Code RA-VAL-CCB-015750

- On 28 September 2012, the Rainforest Alliance verifies that the Makira Forest Protected Area Project is in conformance with the Verified Carbon Standard (VCS) Version 3 under Validation Registration Code RA-VER-CCB-015751. The verification assessment covered the monitoring period from 1 January 2005 to 31 December 2009. Total number of verified emission reductions and/or removals: 989,183 t CO₂-e; Total number of credits to be deposited in the buffer account: 128,594 t CO₂-e

- On 09 September 2013, the Rainforest Alliance validates that the Makira Forest Protected Area Project is in conformance with the Climate, Community and Biodiversity Standards (CCBS) second edition 2008 under Validation Registration Code RA-VAL-CCB-015749.

- in December 2013, at the very end of the current monitoring period, the Prime Minister of Madagascar Omer Beriziky signed the first two Emission Reduction Purchase Agreements (ERPAs) for the sale of 65,369 VCU to Carbon Neutral (on behalf of Microsoft) and 7,000 VCU to Zoo Zurich. Revenues from these two sales are currently being distributed following the REDD+ revenue distribution scheme presented in section 2.1.4, in close collaboration with Tany Meva, the foundation nominated by the Government as the designated foundation for the distribution of the 50% of revenues going to local communities. Prior to these sales, all emission reduction credits verified under the VCS standards in 2012 for the 2005 to 2009 monitoring period have been transferred to a Markit account opened under the name of the Malagasy Government and managed by MCC. The sold credits have been retired from this account (in the case of Zoo Zürich) or transferred to the account of the buyer (in the case of Carbon Neutral).

1.6 Project Crediting Period

The VCS project crediting period for the Makira project will be of thirty years, stretching from January 1st 2005 to December 31st 2034. A detailed financial plan for managing the Makira project over the entire project period can be found in annex 7 of the Makira PD. Projections for expenses in this plan are based on the Makira management plan developed by WCS and approved by MEF in 2010, while expected revenues are based on recent carbon sales and on current negotiations with potential buyers and experience from previous sales.

As mentioned in section 1.5, first sales of emission reduction carbon credits were approved by the Ministry of Environment, Water and Forests in early December 2004 and again in 2008. More recently, credit sales to Carbon Neutral and Zoo Zurich have been signed by the Government in late 2013.
1.7 **Project Location**

The Makira Project, is located in North-eastern Madagascar, 40 km west of the town of Maroantsetra, within the following boundaries: 14º 41' 40.7'' S in the North, 15º 51' 40.8''S in the South, 48º 58' 20.18'' E in the West and 50º 1' 3.7'' E on the East. The Makira Project falls within three regions (Analanjirofo, Sava and Sofia) and five districts (Maroantsetra, Antalaha, Andapa, Befandriana Nord and Mandritsara). The Makira Project involves 21 communes and 63 Fokontany. Figure 2, presents the boundaries of the project zone.

The Makira forests lie within the Antongil Bay landscape and represent one of the largest expanses of humid forest left in the biologically rich Eastern Rainforest Biome of Madagascar. The forests of Makira are a key, intact biodiversity stronghold and a vital bridge maintaining long-term connectivity and altitudinal gradient protection across protected areas in the Northeastern region.

The following spatial boundaries for the Makira have been defined based on the BL-UP module of the applied methodology:

- The Reference area for analysing and projecting rates of Deforestation (RRD)
- The Reference area for analysing and projecting Localisation of deforestation (RRL)
- The Project Area (PA), constituted by all forests (2005) inside the Makira protected area.
- The Leakage Belt (LB) made up by a 10-km buffer around the project area.

Details on these areas are provided in table 1 and figures 3 and 4 below.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Total area 2005 [ha]</th>
<th>Forest 2005 [ha]</th>
<th>Non forest (savannah, agriculture, villages, etc.) [ha]</th>
<th>Forest cover</th>
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<tr>
<td>Project area (2005)</td>
<td>360,060</td>
<td>360,060</td>
<td>0</td>
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<tr>
<td>(forests in protected area including in the 5 ZOC and 15 ZUC)</td>
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<tr>
<td>Leakage Belt (2005)</td>
<td>606,847</td>
<td>341,469</td>
<td>265,378</td>
<td>56%</td>
</tr>
<tr>
<td>(10-km buffer around PA, including management transfers)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRD (1995)</td>
<td>681,225</td>
<td>681,225</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>RRL (1995)</td>
<td>979,340</td>
<td>712,192</td>
<td>267,148</td>
<td>73%</td>
</tr>
</tbody>
</table>

Source: WCS Madagascar GIS Unit, 2010
Figure 3: The different spatial areas of the Makira project: Project area (PA), Reference Area for Deforestation (RRD), Reference Area for Localisation (RRL) and Leakage Belt (LB)
Figure 4: Situation of the RRL and its two main components project area and leakage belt highlighting neighbouring protected areas.
1.8 Title and Reference of Methodology

The methodology applied to the Makira project is the REDD Methodology Framework (REDD-MF), Approved VCS Methodology VM0007, Version 1.4, developed by Avoided Deforestation Partners (ADP). The REDD Methodology Framework is a compilation of modules and tools that together define the project activities and necessary methodological steps. The methodology applies to project activities reducing emissions from planned and unplanned deforestation as well as from forest degradation caused by the extraction of wood for fuel.

For a detailed list and description of methodology modules applied during project development, please refer to section 2.1 of the Makira project description. For the present monitoring report the M-MON Module (version 2.0): “VMD0015 Methods for monitoring of greenhouse gas emissions and removals” has been mainly used.

This methodology module monitors:

- The area of forest land converted to non-forest land and associated changes in carbon stocks;
- The area of forest land undergoing loss in carbon stock from degradation activities and associated changes in carbon stocks;
- The area of forest land undergoing gain in carbon stock from enhancement activities and associated changes in carbon stocks.
- The greenhouse gas emissions associated with project implementation.
- The area of forest land undergoing loss in carbon stocks resulting from natural disturbances and associated changes in carbon stocks.
2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activities

Implementation of the Makira project during the present January 2010 to December 2013 monitoring period was based on the project’s following main activity groups:

- Creation and sustainable management of the Makira protected area
- Development of co-management structures for the Makira protected area
- Building structures and capacities for local sustainable natural resources management
- Support rural development and alternative revenue creation
- Creation of equitable benefit sharing mechanisms

The main stakeholders involved with the implementation of the Makira project were:

- Local communities including notable, farmers, cattle-herders, small-scale miners
- Regional, District and Commune administrative authorities
- Regional and national representatives of the Ministry of the Environment, Water and Forests, especially the forestry department
- Local NGOs and associations
- National and international NGOs

Consultations with these stakeholders, from the national to the local level, were initiated as early as 2001 through social and biological inventories conducted in the context of the creation of the protected area. They have been on-going since and have taken place during each phase of the project cycle, from work plan elaboration to monitoring of the project’s activities outlined in the sections below.

2.1.1 Creation and sustainable management of the Makira protected area

2.1.1.1 Delimitation and Creation of the Protected Area

Delimitation activities and related consultations with stakeholders conducted at the start of the project to create the Makira protected area are described in the previous 2005-2009 monitoring report. This process led to the temporary creation of the Makira protected area in December 2005 and ultimately to definitive creation of Makira Natural Park by decree1 on June 19, 2012.

Following this creation decree, Makira Natural Park’s Core Protected Area covers a total of 372,470 ha and is subdivided in the zone of strict protection, zones for controlled occupation and zones for controlled use, as described below and in table 2. The decree also mentions the 351,037 ha protection zone, where use of natural resources by local communities is restricted. Management authority for forests in this area is being transferred to local community associations with support from the Makira project following the GCF (Gestion Contractualisée des forêts de l’Etat) procedures laid out in decree n° 2001-1222 (see section 2.1.2 below for more detail on the management transfer process).

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1 Décret n° 2012-641 du 19 juin 2012 portant création du Parc Naturel « MAKIRA » sis dans les régions d’Analanjirofo, de Sofia et de SAVA
2 Décret n° 2001-122 du 14 février 2001 fixant les conditions de mise en oeuvre de la Gestion Contractualisée des Forêts de l’Etat
The management plan of Makira Natural Park describes the three main zones as follows (cf. table 2 and figure 5 below):

- **Zone of Strict Protection**: Designated within the Core Protected Area and in which no commercial or subsistence harvests or removals are allowed.

- **Multiple Use Zones**: Designated within the Core Protected Area as a result of consultations with local populations. The multiple use zones include:
  
  - **Controlled Occupation Zones** (Zones d’Occupation Contrôlée or ZOC): Areas inside the Makira core protected area where small resident populations will remain living within the park, but where immigration is strictly prohibited. WCS Madagascar is the delegated manager of the core protected area appointed by the government and unlike similar areas in the protection zone (see below) no transfers for management of natural resources are promoted by the project.
  
  - **Zones of Sustainable Use** (Zones d’Utilisation Contrôlée or ZUC) that are uninhabited agricultural areas occurring within the Core Protected Area, and where natural resource use for specific subsistence purposes is permitted, but neither commercial mining nor logging are allowed. These zones also can not be included into management transfers but WCS supports the development and implementation of management plans in order to maintain natural resources use sustainable on the long run.

- **Protection Zone**: This zone is made up of community based forest management sites, where management responsibility has been officially devolved to communities living along the perimeter of the forest through a contract between the ministry of forests and elected communal forest authorities. Each GCF site has its own development and zoning plan, which includes i) forest and non-forest areas that are lived in and used by communities and ii) a buffer of forest bordering the Core Protected Area that is the community’s conservation zone.

### Table 2: Zoning of Makira Protected area and its protection zone

<table>
<thead>
<tr>
<th>Designation</th>
<th>Units</th>
<th>Sub-Units</th>
<th>Number</th>
<th>Area [ha]</th>
<th>Management Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protected Area</td>
<td></td>
<td>Zone of Strict Protection or Noyau Dur</td>
<td>-</td>
<td>1</td>
<td>331,993 Forests under strict protection with no commercial or subsistence harvests or removals allowed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone of Controlled Settlement / Occupation (ZOC)</td>
<td>5</td>
<td>11,875</td>
<td>Zones (mostly non forested within the protected area where people live and where no extension of settlement or immigration is allowed. Inhabitants are registered. Subsistence activities (agriculture and cattle-grazing) are allowed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone of Sustainable Use (ZUD)</td>
<td>15 (6 community and 9 individual)</td>
<td>28,602</td>
<td>Zones (forested) within the protected area where use of natural resources for subsistence is permitted. Commercial mining and logging are forbidden. Permanent settlement is forbidden</td>
</tr>
<tr>
<td>Protection zone</td>
<td>Community-managed sites</td>
<td>80 GCF sites</td>
<td></td>
<td>351,037</td>
<td>Each GCF site includes a conservation zone and an area for customary use</td>
</tr>
</tbody>
</table>

Note: Areas in this table are total areas and include forest and non-forest areas. The project area, as presented in table 1 and section 1.7, is constituted only by the forests inside the Makira protected area in 2005 and therefore slightly smaller than the total area presented above.
Figure 5: The Makira Protected Area (including ZUC and ZOC) and surrounding protection zone constituted by management transfers (forest cover 2005)
2.1.1.2 Management of the protected area

As with most natural forests in Madagascar, the government officially owns the forests in Makira and no private ownership of forest lands can be claimed. In 2003, the Ministry in charge of the Environment and Forest granted WCS exclusive official management delegation of the Makira Area. Following the management delegation contract, WCS represents the forest administration as manager of the Makira Protected Area and therefore has control over all the activities that are conducted in it and also has the right to enforce national and regional regulations regarding natural resources and protected area management.

The initial management delegation contract was valid until 2008 and the extension of the contract was long delayed due to the political instability that started in 2009. Renewal of the management delegation contract has accelerated following additional funding from the World Bank for the national Environmental Program phase 3 (PE3), and in December 2011, ministerial order 45.330/2011/MEF\(^3\) named WCS as delegated manager of the Makira protected. Based on this text, a new management delegation contract, integrating detailed obligations and responsibilities for both parties, has been developed in early 2012 and signed by the Ministry for Environment and Forests on Mai 2\(^{nd}\) 2012. The following specific activities to support sustainable management and reduce deforestation and forest degradation were implemented by WCS during the 2005 – 2013 monitoring period:

- Create basic infrastructures for the Makira Protected Area management team, including a management office, equipment, transport, communication and administrative needs. In December 2013, three new offices for sector I (Ambinanitelo - Maroantsetra District), sector IV (Belalona - Befandriana North District) and sector V (Andapa - Andapa District) have been built and equipped with furniture. Three offices, including one for the Direction of the PNAT Makira in Maroantsetra and two for sector II (Blanana - District Maroantsetra) and sector III (Mandritsara - District Mandritsara) are currently being finalized. In addition WCS is negotiating an agreement with the Ministry of Environment and Forests representative in Antalaha for the building of the office for sector VI. All park offices will be equipped with communications systems aiming to facilitate liaison between them and with the head office in Maroantsetra. Some offices will also be equipped with e-mail and internet access, while offices located far from zones covered by mobile phone networks will be equipped with BLU.
- An environmental and social impact assessment (EIES) was conducted in 2008 under the supervision of ONE (Office National pour l'Environnement).
- Based on the EIES, and environmental and social management plan was developed and approved by ONE in January 2009 through deliverance of an environmental permit (cf. annex 5).
- In 2009, WCS developed a simplified management plan (PAGS) for the protected area integrating environmental and social aspects of protected area management. The management plan was approved and updated in 2011 for inclusion into the dossier submitted to MEF for issuance of the definitive protection status.
- Development of a 10-year business plan for the protected area started in 2011 and a first version of a 25-year (2010 to 2034) business plan for the Makira project, including carbon finance aspects, was completed in early 2012.
- In late 2011, additional World Bank funding to the third phase of the Environment program (FAPE3) also led to improvements of methodologies and implementation of the following PA management activities:
  - General research and scientific monitoring programme conducted inside the protected area to improve knowledge essential for the long-term management and protection of the Makira Forests.

\(^3\) Arrêté n° 45.330/2011/MEF du 14 décembre 2011 portant délégation de gestion de la Nouvelle Aire Protégée dénommée "Makira"
Figure 7: Situation of the transfer of forest management authority to local communities (GCF sites) around the Makira protected area in January 2014 (cf. annex 9)
o Information management system and database at landscape level to assist management of the Makira Project. The database also contains all information relevant for monitoring deforestation, forest degradation, carbon stocks and emission reductions.

o Participatory ecological monitoring programme (cf. section 2.1.2 for more detail).

o Reliable control and supervision system to ensure law enforcement within the protected area. In close collaboration with local and regional authorities, Gendarmerie, Police and other partners. During the current monitoring period the project organized several multi-party control missions into the protected area and the frequency of these missions will increase in subsequent years. During these joint missions, about 350 small camps of gold miners have been demolished and about 500 gold miners have been evacuated from the protected area and the protection zone. The project also supported prosecution of the illegal agents and as a result eight miners have been fined, 8 miners have been condemned without prison and one illegal miner has been condemned to a 4-month prison term.

o Development of an approved safeguards program in communities affected by the new protected area following World Bank procedures and implementation of safeguards monitoring processes. By the end of the study, 2,447 individuals have been identified as belonging to the Population Affected by the Project (PAP) to create Makira Natural Park and whose losses and restrictions have to be compensated. Four types of compensation projects have been proposed by the study: i) Improved rice production as alternative to slash and burn agriculture for 1,234 PAPs; ii) Poultry farming as an alternative to bushmeat hunting for 321 PAPs; iii) Bee keeping as an alternative to collecting wild honey for 587 PAPs; and iv) pig farming as an alternative to illegal logging for 305 PAPs.

2.1.1.3 Development of co-management structures for the Makira protected area

Besides the zoning and delimitation of the Makira protected area and the surrounding protection zone, the multi-stakeholder consultations outlined in the previous section also led to the development of a co-management structure for the Makira protected area. The overall co-management structure includes government, community and NGO representatives and is made up of the following three committees (cf. figure 6):

• The steering and monitoring committee (the decision-making body)
• The management committee
• The advisory committee which includes external actors who influence or are influenced by the protected area

In this co-management structure, the GCF site management committees (known as COGEs) are organized into 6 sector platforms, with each providing representatives to the COGE federation that directly engages in the Makira steering and management committees. The organization of the local communities within the Protection zone is as follows (cf. figure 6):

• Each community-managed GCF site has a management committee (called COGE) that identifies two representatives to be part of the COGE platform of its sector. Each COBA organizes at least two general assembly meetings per year: The first meeting serves to discuss activities and budget for the current year and to report on activities conducted during the previous year; The second meeting is organized mainly for a mid-term assessment of implemented activities and results, as well as approval of new membership application to the COBA.
• Each sector (cf. figure 5) has a COGE platform that discusses issues related to management of their GCF sites in relation to the Makira protected area. Each sector platform identifies two representatives to be part of the COGE Federation. Sector IV is the sole sector that will have 3 representatives given the large number of GCF and ZOC sites. By the end of 2013, six
platforms as well as the Federation of COBAs around the Makira NTP were created. As mentioned above they usually organize two General assembly meetings per year and each platform received several training session on different topics including activity planning, association leadership and organisation, conflict management, etc.

• Created in April 2012, the Federation of COGEs finally, will then select three representatives (one representative per region) to be part of the Makira PA steering committee. The three representatives of the COGE Federation have already participated at the annual meetings of the Makira steering committee (cf. figure 4) since 2013

This structure ensures a high degree of participation of local communities in the Makira management and steering committees and thus in all decisions made concerning activities in the different zones of Makira PA, as well as within the Protection Zone. In close collaboration with WCS, the COGEs currently implement the following activities to ensure sustainable management and conservation of forest resources in the project area:

• Work with partners in the identification and development of sustainable financing mechanisms fostering linkages between forest conservation and community livelihoods.

• Work with local decision-makers and communities to establish local resources management and development plans (“Plan Communautaire de Développement” PCD).

• Develop, in partnership with all stakeholders at regional level, a comprehensive land use plan for the larger MaMaBay (Makira PA, Masoala NP and Antongil Bay) landscape, establishing a regional natural resource management strategy. The MaMaBaie land use plan including, Tampolo ecotourism zone in the western cost of Masoala National Park, the coastal and the Antongil Bay fishery management plan and the Makira and Masoala green belt management plan is validated after a regional workshop in Maroantsetra organized by the PCDDBA. Several participants including local and regional authorities, Ministry representatives, Federations of Fishermen, Federation COBAs, and major stakeholders concerned by the different themes have participated in this workshop.

2.1.2 Building structures and capacities for local sustainable resource management

From early on integration of local communities into natural resources management was an essential aspect of the protection of the Makira forests. Consequently, the Makira project has been supporting local community associations in being appointed as delegated managers of natural forests in the Protection Zone, following the official GCF (Gestion Contractuelle des Forêts de l’Etat) procedures. Under GCF, contracts are signed between the government and the representative of the COBAs, the Community Management Committee (COGE). Because of the length of the applied procedures and the number of concerned communities, the process is currently still ongoing.

As of December 2013, at the end of the current monitoring period, 62 community-managed areas, covering a total area of about 250’000 ha, including more than 125,000 ha of natural dense forest (in early 2014), have been officially created out of a total of 80 necessary for completely surrounding the Makira protected area with a community protection zone (cf. figure 7 and annex 9). These 62 community managed sites count 44,264 inhabitants in 8,546 households. It is also important to note that according to legislation, contracts must be assessed and renewed after three years. In December 2013, 21 contracts evaluated positively were renewed for a second period of ten years. However, all 80 forest management transfer areas have already been tentatively delimited and all involved communities have informally adhered to the process. It is therefore unlikely that any of the remaining 28 communities will retract from the management delegation process. As WCS has already secured funds from various sources to finalize the remaining management transfers, it is expected that all management transfers will become effective by the end of 2015.
On the level of the newly created community associations for forest management in the areas surrounding the protected area, WCS implemented the following activities:

- **Strengthen capacities of community forestry associations to sustainably manage and monitor forest and pasture resources used in the protection zone:**
  - **Animators:**
    Base project staff is based directly in the communities having signed forest management contracts (one animator for two villages or CoBas) in order to keep close contact with the problems and aspirations of local communities and supervised by regional responsible (chefs de secteur). 16 animators are currently operational among the forest managing communities inside and around Makira Natural Park, supervised by two “chefs de secteur” based in Andapa and in Maroantsetra.
  - **Training events:**
    The project provided capacity-building opportunities on various themes relevant for community based sustainable natural resources management such as community organization, social mobilization, themes relevant for the functioning of the village associations and techniques for sustainable management and monitoring of natural resources. 48 training events and 8 exchange visits have thus been organized by the project and been attended by members of the forest managing communities.
  - **Material support:**
    In order to facilitate operationalization of the CoBas in general and the forest management committees in particular and assist them in assuming their new management responsibilities, the Makira project has also provided material support to the newly created structures (CoGes, CoBa Platforms and CoBa Federation). This material support was very diversified and based on the immediate needs of the newly created natural resources management structures but contained generally office furniture (tables, chairs, etc.) and supplies (paper, writing material, forms, stamps, etc.) general supplies, working clothes (field vests, rain coats, etc.) and information panels to be set up on the boundaries of the community managed areas and the main villages. 18 CoBas have thus been provided with general supplies, 18 have received office furniture, and 51 were provided with working wear and office supplies.

- **Develop and implement an Information, Education and Communication (IEC) program to support sustainable community development.**
  - As of December 2013, more than 900 IEC activities, campaigns and events have been implemented by the Makira project. They include multimedia communication campaigns to promote awareness for conservation and sustainable resource use, a 1 hour weekly radio program, production and distribution of a trimestral news bulletin, as well as programmed field outreach missions with town hall style discussions about environmental issues, film screenings and environmental education with school children and youth. In addition, campaigns to prevent certain diseases and promote family planning were conducted involving more than 32,200 people in and around Makira Natural Park. Finally, the project helped to develop at least 20 curricula and communication tools for communities linking natural resources, livelihoods, and environmental health. As for planning familial, 9,300 women are currently using contraceptive methods and more than 7,000 condoms have been distributed.
• Develop and implement tools for communities linking natural resources, livelihoods, and environmental health:
  
  **Participatory monitoring system:**

  In parallel with the scientific ecological monitoring systems concentrated on the protected area itself, WCS thus started developing and implementing participatory ecological monitoring approaches focusing on forests and other ecosystems inside the community managed areas of the protection zone. The system will be implemented by participatory ecological monitoring committees set up at the level of the local community associations and by December 2012, more than 30 of these committees were operational in all 6 sectors of the Makira project (cf. figure 7).

2.1.3 Support rural development and alternative revenue creation

The Makira Forest Project includes a significant number of interventions to enhance the welfare of local communities and their management of resources. Activities were based on consultations and socio-economic studies and paid particular attention to improving access and quality of health services and education, addressing need for improved agricultural techniques and creating links to new markets and livelihoods.

In order to facilitate transfer of knowledge of the promoted improved agricultural techniques, WCS adopted the "Farmer to Farmer" approach. In 2013, WCS has worked in collaboration with 35 trainer farmers around the park. They are previously trained on various improved agricultural techniques (SRI, bee keeping, fish farming, etc.), then WCS has supported them for the establishment of demonstration canters, where they can organize training campaigns.

The following activities were implemented during the 2010 to 2013 monitoring period:

• Regarding rural development activities (agriculture, agroforestry, and natural forest management) at key locations to minimize leakage and to increase overall project success, the following specific activities were carried out:
  
  **In collaboration with the Better U Foundation (BUF) and the Madagascar Biodiversity Foundation (FAPBM), WCS has provided technical training and material support (agricultural equipment) to promote the use of SRI and SRA techniques for rice cultivation, which have been adopted by many households in the protection zone. By December 2013, about 300 rice farmers practice improved rice cultivation techniques such as SRI / SRA on a total of 130 ha area.**
  
  **In close relation with the activity mentioned above, WCS supported the rehabilitation of 14 small dams for rice irrigation in order to improve irrigation control on more than 1,080 ha of existing rice fields and thus increase productivity. Four irrigation dams, located in sectors I and IV of the project intervention area, have thus been completely rebuilt by the project. They irrigate a total of 355 ha of rice fields cultivated by 159 households.**
  
  **This resulted overall in an increase of productivity among the trained farmers from 3 to 7 tons of paddy rice per hectare. In order to make these achievements permanent, 17 farmers already trained in improved techniques of rice production and the use of the proposed and distributed tools were selected in order to ensure permanent transfer of the promoted techniques to additional interested farmers in the Makira protection zone.**

• WCS also promoted alternative income generating activities such as eco-tourism (see below) and beekeeping by providing capacity building in new techniques and also supplying essential material (modern bee hives). More than 60 households have thus been trained in improved beekeeping techniques.
• WCS also provided organizational and material support to the established management transfers in order to improve their capacities to implement efficient and effective management and control of natural resources:
  o By December 2013, 60 community based ecological monitoring units have been set up distributed over all six sectors of Makira Natural Park’s protection zone. These new structures, trained on how to conduct community based ecological monitoring and equipped by WCS (rain coat, watch, GPS, etc.), conducted two follow-up campaigns to assess the impacts of community management of natural resources on their environment. At the end of each year, these committees organize information campaigns to discuss with their pears the new management strategy to be followed if the evaluation results show fairly high pressures.
  o As of 2013, 55 ground patrol committees were created in the six sectors of Makira Natural Park. These new structures have been trained and equipped by WCS and have conducted joint missions with the forest administration that led to the expulsion of more than 500 illegal gold miners from the protected area.
  o WCS supported the construction of office buildings in all the newly created management transfers and also provides base material and supplies (work wear, office supplies, etc.).

• WCS tried to foster connections between private sector actors and local communities in order to develop ecotourism, enhance market access for local communities and promote environmental friendly and fair trade products:
  o In the villages of Ambodivoahangy and Andaparaty, WCS supported the construction of two eco-tourism sites, including 02 bungalows, 5 tent shelters, camp sites, 8 kilometres of touristic pathway, cooking area and sanitation facilities and promoted contacts between the village association and private tourism operators in Maroantsetra. Two local women’s association with 10 members each have been trained by the project to provide meals for tourists and ensure maintenance of the tourism infrastructures. WCS also provided trainings to 14 local community members as guides for tourists on the installed paths.
  o Support was provided to 2 producers associations to production of biological and fair trade vanilla through training in improved production techniques from planting to preparing vanilla pods and providing them with materials such as thermometers, blankets, etc.
  o WCS also continued its collaboration with Zoo Zürich in promoting biological production of cocoa in the Eastern part of the Makira protection zone. By the end of December 2013, more than 100 households from 7 producers’ associations have planted over 15,000 cocoa trees. A process to create a cooperative of producers was launched in 2013 and samples of about 05 kg of cocoa beans are sent annually in Switzerland for quality control and promotion on international markets.

• With financial support from the Third Environmental Program (EPIII) funded by the World Bank, WCS provided support to promote raffia handicap in the Southwest of Makira. 32 members from two women’s associations have been trained in improved technical production of raphia handicap and equipped with 24 sewing machines and two 4mx4m buildings serving as labor and product sales workshop.

• In order to improve access to micro-finance institutions by communities involved in the Makira project, WCS developed a proposal to the Tany Meva foundation for setting up a micro-credit programme in the commune of Ambinanintelo. The proposal was accepted and lead to the following achievements:
  o In May 2008, the microfinance institution OTIV decided to open a local office in Ambinanintelo, a locality lying relatively close to the Southwestern border of the Makira project. As of December 2013, 1,475 organizations and individuals requested membership, of which 93 were community associations closely related to the Makira project. During the reported period, the amount of savings is estimated at more than $125,000 and the volume of the credit contracted is about US$122,800
In order to expand the community development program to include population, health and environment components (PHE) to improve family health, WCS collaborated with MEDAIR in improving sanitation and water supply in the area.

2.1.4 Creation of equitable benefit sharing mechanisms

The Government of Madagascar is the clear owner of Makira Natural Park and thus also considered the owner of all emission reduction carbon credits generated by the Makira Project. In June 2008, the Government of Madagascar and Makira Carbon Company (MCC), a wholly-owned subsidiary of WCS, developed an agreement outlining roles and responsibilities as well as the carbon revenue sharing and management mechanism for the Makira Project.

This agreement (2008 Agreement) was ratified by decree No. 2008-704 dated 11 July 2008 in a Council of the government of Madagascar, as further amended on 16 July 2012. The 2008 Agreement appoints MCC as the Government of Madagascar’s exclusive agent for the marketing and sale of at least 32.5 million metric tons (or such other amount as may be determined by third party verification) of verified emission reduction credits generated by the Project from the Makira Forest to the public.

The net proceeds for the sales of Makira emissions offsets will be allocated as follow (cf. figure 8):

(i) 50% to support local communities in and around the Makira Forest in their natural resource management, forest conservation and community development initiatives, through a defined local management structure to be established in accordance with applicable Malagasy law. Allocation of funds will be determined by a steering committee within the Designated Foundation in collaboration and consultation with the delegated manager of the Makira Protected Area.

(ii) 20% to the delegated manager of the Makira Protected Area to support the management of the Makira Protected Area pursuant to the Management Delegation Agreement or such other applicable agreement, as the case may be.

(iii) 20% to the Ministry, to support a range of activities including strengthening its technical capacity for climate change mitigation and supporting the development of a national carbon strategy and national monitoring capacity.

(iv) Up to 5% to reimburse MCC for expenses incurred in connection with the promotion and marketing of the Allocated Carbon Offsets (and the management of such promotion and marketing).

(v) Up to 2.5% to MCC to pay for third party monitoring, verification and certification, with any portion of the 2.5% not so expended to be allocated to (i).

(vi) Up to 2.5% to the “Designated Foundation” for its overhead costs in association with the management and disbursement of funds made available under the Agreement.

The agreement also defines the roles and responsibilities of a “designated foundation” in managing the funds generated by the sale of emission offsets from the Makira project. Most importantly, the foundation will manage the allocation of the 50% to support local communities and the 20% to support the management of the Makira protected area, under the supervision of a steering committee with representatives from all stakeholders. While funds for protected area management will be allocated following the approved management plan and the management delegation contract, an additional agreement regarding the allocation of the 50% for supporting local communities will be developed between the designated foundation, the State and the delegated manager of the Makira protected area.
While negotiations on the sale of carbon credits were still ongoing, WCS did not yet communicate and discuss potential revenues and their use with local communities in order to avoid creating overenthusiastic expectations. It has also be noted that the State and not WCS is the owner and seller of emission offsets generated by the Makira project and until very recently no official strategy for communicating on carbon benefits to local communities has been issued. However, negotiations advanced substantially and WCS developed a carbon communication plan that is currently being implemented at local level.

Through December 31, 2011, a total of 154,329 tCO₂-e of emission reductions from the Makira Project were sold upfront to help financing the establishment of the project. These sales were carried out by the Conservation International Center for Environmental Leadership in Business, and maintained in an internal project registry. These 154,329 t CO₂-e have been deducted from the number equivalent to the total tCO₂-e of emission reductions eligible to be issued as VCU's generated by the Makira Project.

It has however to be noted that revenues from these sales have not been distributed following the revenue distribution scheme presented above. With the agreement from the Ministry of Environment and Forests, owner of the sold emission reduction credits, the entire revenue from the two sales was invested into further project development through two contracts signed between the three involved parties in December 2004 and in July 2008 respectively.

In December 2013, at the very end of the current monitoring period, the Prime Minister of Madagascar Omer Beriziky signed the first two Emission Reduction Purchase Agreements (ERPs) for the sale of 65,369 VCU's to Carbon Neutral (on behalf of Microsoft) and 7,000 VCU's to Zoo Zurich. In order to make these and later transactions possible, MCC, on behalf of the Government of Madagascar, opened a specific MarkIt account to register and transfer emission reduction credits generated by the Makira project.

In parallel, the Government also designated the national Tany Meva foundation as the foundation designated to manage the 50% of REDD revenues going to local communities (cf. figure 8 above). Currently, WCS is working with Tany Meva and the Ministry for Environment, Ecology and Forests.
2.2 Deviations from the Monitoring Plan

The following deviations from the monitoring plan (cf. section 3.3 below) have to be mentioned:

- Monitoring land use change (cf. sections 3.3.3 and 4.3.1.1):

  A minor methodological change concerns the classification algorithm used for assessing land use change in the project area and in the leakage belt during the monitoring period. For the 2005 – 2009 land use change assessment the “Maximum Likelihood” algorithm integrated into the Land Change Modeler software has been used for classification of satellite images. During the current monitoring period, the team decided to use the “RandomForest” algorithm in combination with the statistical software package R.

  The two approaches have been tested during the AFD funded REDD+ methodological support project implemented by Office National pour l’Environnement (ONE) and Helvetas Swiss Intercooperation in 2013/14. The main conclusions of this assessment are the following (cf. annex 13 for more detail):

  - Advantages:
    - The PHCF approach using the “RandomForest” algorithm leads to a more accurate assessment of forest cover and forest cover change, particularly in the humid forest ecoregion.
    - The process for identifying and delimitating the training sites is straightforward and simpler than the one under the CI Approach and differences between photo interpreters are reduced.
    - The used software R and GRASS GIS are both free and open source software accepting scripts. Satellite image classification is conducted automatically based on the satellite images and the training sites and thus completely replicable and transparent.

  - Disadvantages:
    - Used software is less known and less user friendly than the propriety ERDAS software used by most conservation projects.

  Based on this evaluation of the two approaches, the PHCF approach using the “RandomForest” algorithm was selected as the standard approach for forest cover change assessment in Madagascar at the REDD+ methodology workshop held in December 2013 and consequently this approach was also adopted by the Makira REDD+ project. However, in order to maintain comparability between the 2012 and 2014 forest cover change assessments, the filtering process used in the forest cover change assessment during the first monitoring period, 1 ha for forest and deforestation, was maintained for the second one.

2.3 Grouped Project

Not applicable.
## DATA AND PARAMETERS

### 3.1 Data and Parameters Available at previous Verification

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Forest Cover Monitoring Map (2010)</td>
<td>Forest cover in the project area (PA) and in the leakage belt (LB) at the end of the previous monitoring period (Jan. 01, 2005 to Dec. 31, 2009).</td>
</tr>
<tr>
<td>Data unit:</td>
<td>ha</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Remote sensing (two Landsat scenes, historic high-resolution data from Google Earth for ground-truthing)</td>
</tr>
</tbody>
</table>

**Description of measurement methods and procedures to be applied:**

Map accuracy assessed by comparing the final map with groundtruthing data from Google Earth. Minimum map accuracy 90%

**Frequency of monitoring/recording:**

Initially every five years or prior to any exceptional verification event, annually for the second monitoring period 2010 – 2013.

**Value monitored:**

- **PA:** 358,045 ha
- **LB:** 335,093 ha

**Monitoring equipment:**

ERDAS IMAGINE software for image interpretation and ARC GIS software for mapping and forest cover calculations.

**Calculation method:**

Calculation of 2010 forest cover for PA and LB based on 2010 forest cover map established from the 2012 satellite image analysis.

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>A&lt;sub&gt;i&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Ha</td>
</tr>
<tr>
<td>Description:</td>
<td>Total area of forest stratum I in the project area at the end of the previous monitoring period (Jan. 01, 2005 – Dec. 31, 2009)</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Remote sensing data</td>
</tr>
</tbody>
</table>
| Value applied:   | • Low Altitude Forest: 124,509 ha  
                   • Mid Altitude Forest: 233,536 ha |

**Measurement methods and procedures applied:**

Overlapping project area map with strata boundaries.

**Any comment:**

Data from the 2012 forest cover analysis. Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Based on preliminary inventories only three strata have been identified: Low and mid altitude forest and post-deforestation.

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>A&lt;sub&gt;i&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Ha</td>
</tr>
<tr>
<td>Description:</td>
<td>Total area of forest stratum I in the leakage belt at the end of the previous monitoring period (Jan. 01, 2005 – Dec. 31, 2009)</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Remote sensing data</td>
</tr>
</tbody>
</table>
| Value applied:   | • Low Altitude Forest: 225,984 ha  
                   • Mid Altitude Forest: 109,109 ha |

**Measurement methods and procedures applied:**

Overlapping project area map with strata boundaries.

**Any comment:**

Data from the 2012 forest cover analysis. Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Based on preliminary inventories only three strata have been identified: Low and mid altitude forest and post-deforestation.
<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$A_{\text{DefPA},i,t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>ha</td>
</tr>
<tr>
<td>Description:</td>
<td>Total area of recorded deforestation in the project area (PA) in stratum i during the previous monitoring period (January 2005 – December 2009)</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Remote sensing imagery</td>
</tr>
<tr>
<td>Description of measurement methods and procedures to be applied:</td>
<td>Compare forest cover maps based on subsequent remote sensing imagery to assess change</td>
</tr>
<tr>
<td>Frequency of monitoring/recording:</td>
<td>Every five years or prior to any exceptional verification event</td>
</tr>
</tbody>
</table>
| Value monitored: | • Low Altitude Forest: 562 ha  
• Mid Altitude Forest: 1,453 ha |
| Monitoring equipment: | ARC GIS software for mapping and forest cover calculations |
| Calculation method: | 2005 forest cover in Project area minus 2010 forest cover in Project Area. Data from 2012 analysis. |

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$A_{\text{DefPA},i,t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>ha</td>
</tr>
<tr>
<td>Description:</td>
<td>Total area of recorded deforestation in the leakage belt (LB) in stratum i during the previous monitoring period (January 2005 – December 2009)</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Remote sensing imagery</td>
</tr>
<tr>
<td>Description of measurement methods and procedures to be applied:</td>
<td>Compare forest cover maps based on subsequent remote sensing imagery to assess change</td>
</tr>
<tr>
<td>Frequency of monitoring/recording:</td>
<td>Every five years or prior to any exceptional verification event</td>
</tr>
</tbody>
</table>
| Value monitored: | • Low Altitude Forest: 3,289 ha  
• Mid Altitude Forest: 3,086 ha |
| Monitoring equipment: | ARC GIS software for mapping and forest cover calculations |
| Calculation method: | 2005 forest cover in Project area minus 2010 forest cover in Project Area. Data from 2012 analysis. |

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$C_{\text{BSL},i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>t CO$_2$-e/ha</td>
</tr>
<tr>
<td>Description:</td>
<td>Average carbon stock in biomass in all carbon pools in stratum i</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Field measurements</td>
</tr>
</tbody>
</table>
| Value applied:   | • Low Altitude Forest: 544.89 tCO$_2$-e/ha  
• Mid Altitude Forest: 810.14 tCO$_2$-e/ha  
• Post-deforestation: 238.89 tCO$_2$-e/ha |
| Justification of choice of data or description of measurement methods and procedures applied: | Obtained through combining average carbon stock in all considered pools (cf. inventory methodology in annex 1) |
| Any comment:     | Low altitude forest: 0-800m; mid altitude forest: 800-1,800m. The initial inventory conducted in the Makira project area showed no significant difference in carbon stocks between degraded and intact forests. In consequence only three strata have been identified: Low and mid altitude forest and post-deforestation |

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$C_{\text{AB-tree},i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>t CO$_2$-e/ha</td>
</tr>
<tr>
<td>Description:</td>
<td>Average carbon stock in above ground tree biomass in stratum i</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Field measurements</td>
</tr>
</tbody>
</table>

Makira Forest Protected Area Project; 2010 to 2013 Monitoring Report; version 3.3
### Value applied:

- Low Altitude Forest: 391.78 tCO$_2$-e/ha
- Mid Altitude Forest: 609.59 tCO$_2$-e/ha
- Post-deforestation: 177.51 tCO$_2$-e/ha

### Justification of choice of data or description of measurement methods and procedures applied:

Carbon pool mandatory in applied methodology. Biomass obtained through sampling inventory in all forest strata (cf. inventory methodology in annex1) and with allometric function, carbon stock through applying carbon content factor.

### Any comment:

The initial inventory conducted in the Makira project area showed no significant difference in carbon stocks between degraded and intact forests. In consequence only three strata have been identified: Low and mid altitude forest and post-deforestation.

---

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$C_{BB_tree_i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data unit:</strong></td>
<td>t CO$_2$-e/ha</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>Average carbon stock in below ground tree biomass in stratum $i$</td>
</tr>
<tr>
<td><strong>Source of data:</strong></td>
<td>Field measurements</td>
</tr>
<tr>
<td><strong>Value applied:</strong></td>
<td></td>
</tr>
<tr>
<td>• Low Altitude Forest:</td>
<td>94.03 tCO$_2$-e/ha</td>
</tr>
<tr>
<td>• Mid Altitude Forest:</td>
<td>146.30 tCO$_2$-e/ha</td>
</tr>
<tr>
<td>• Post-deforestation:</td>
<td>42.60 tCO$_2$-e/ha</td>
</tr>
</tbody>
</table>

### Justification of choice of data or description of measurement methods and procedures applied:

Carbon pool mandatory in applied methodology. Biomass obtained through conversion factor from $C_{BB\_tree\_i}$, carbon stock through applying biomass carbon content.

### Any comment:

The initial inventory conducted in the Makira project area showed no significant difference in carbon stocks between degraded and intact forests. In consequence only three strata have been identified: Low and mid altitude forest and post-deforestation.

---

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$C_{SDW_i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data unit:</strong></td>
<td>t CO$_2$-e/ha</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>Average carbon stock in standing dead wood biomass in stratum $i$</td>
</tr>
<tr>
<td><strong>Source of data:</strong></td>
<td>Field measurements</td>
</tr>
<tr>
<td><strong>Value applied:</strong></td>
<td></td>
</tr>
<tr>
<td>• Low Altitude Forest:</td>
<td>16.68 tCO$_2$-e/ha</td>
</tr>
<tr>
<td>• Mid Altitude Forest:</td>
<td>33.99 tCO$_2$-e/ha</td>
</tr>
<tr>
<td>• Post-deforestation:</td>
<td>2.08 tCO$_2$-e/ha</td>
</tr>
</tbody>
</table>

### Justification of choice of data or description of measurement methods and procedures applied:

Carbon pool not mandatory in applied methodology but significant in project area. Biomass obtained through sampling inventory in all forest and post-deforestation strata (cf. inventory methodology in annex1) and with allometric function, carbon stock through applying carbon content factor.

### Any comment:

The initial inventory conducted in the Makira project area showed no significant difference in carbon stocks between degraded and intact forests. In consequence only three strata have been identified: Low and mid altitude forest and post-deforestation.

---

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$C_{LDW_i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data unit:</strong></td>
<td>t CO$_2$-e/ha</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>Average carbon stock in lying dead wood biomass in stratum $i$</td>
</tr>
<tr>
<td><strong>Source of data:</strong></td>
<td>Field measurements</td>
</tr>
</tbody>
</table>
Value applied:
- Low Altitude Forest: 42.40 tCO₂-e/ha
- Mid Altitude Forest: 20.26 tCO₂-e/ha
- Post-deforestation: 14.68 tCO₂-e/ha

Justification of choice of data or description of measurement methods and procedures applied:
Carbon pool not mandatory in applied methodology but significant in project area. Biomass obtained through sampling inventory in all forest and post-deforestation strata (cf. inventory methodology in annex1) and with allometric function, carbon stock through applying carbon content factor

Any comment:
The initial inventory conducted in the Makira project area showed no significant difference in carbon stocks between degraded and intact forests. In consequence only three strata have been identified: Low and mid altitude forest and post-deforestation

3.2 Data and Parameters Monitored

Data / Parameter: Regional Forest Cover Monitoring Map 2010
Data unit: ha
Description: Forest cover in the project area (PA) and in the leakage belt (LB) at the start of the current monitoring period (early 2010).
Source of data: Remote sensing (two Landsat scenes, high-resolution data from Google Earth for ground-truthing)
Description of measurement methods and procedures to be applied: Map accuracy assessed by comparing the final map with ground-truthing data from Google Earth. Minimum map accuracy 90%
Frequency of monitoring/recording: Annually
Value monitored:
- PA: 358,093 ha
- LB: 290,621 ha
Monitoring equipment: ERDAS IMAGINE software for image interpretation and ARC GIS software for mapping and forest cover calculations
Calculation method: Calculation of 2010 forest cover for PA and LB based on 2010 forest cover map established from the satellite image analysis
Any comment: The previous monitoring report assessed the 2010 forest cover as follows (cf. section 3.1):
- PA: 358,045 ha
- LB: 335,093 ha
Differences are due to erroneous image interpretation in the previous analysis and consequently data from the new analysis conducted by PERR-FH has been used (cf. section 4.3.1.1)
### Data / Parameter: \( A_i \)

<table>
<thead>
<tr>
<th>Data unit:</th>
<th>Ha</th>
</tr>
</thead>
</table>

### Description:
Total area of forest stratum \( i \) in the project area (PA) at the start of the current monitoring period (early 2010).

### Source of data:
Remote sensing data.

### Description of measurement methods and procedures to be applied:
Overlapping 2010 forest cover in Project Area and Leakage Belt with strata boundaries.

### Frequency of monitoring/recording:
Annually.

### Value monitored:
- Low Altitude Forest: 119,030 ha
- Mid Altitude Forest: 239,063 ha

### Monitoring equipment:
ERDAS IMAGINE software for image interpretation and ARC GIS software for mapping and forest cover calculations.

### Calculation method:
Calculation of 2010 forest cover for PA and LB based on 2010 forest cover map established from the satellite image analysis.

### Any comment:
The previous monitoring report assessed the 2010 forest cover as follows (cf. section 3.1):
- Low Altitude Forest: 124,509 ha
- Mid Altitude Forest: 233,536 ha

Differences are due to erroneous image interpretation in the previous analysis and consequently data from the new analysis conducted by PERR-FH has been used (cf. section 4.3.1.1).

---

### Data / Parameter: \( A_i \)

<table>
<thead>
<tr>
<th>Data unit:</th>
<th>Ha</th>
</tr>
</thead>
</table>

### Description:
Total area of forest stratum \( i \) in the leakage belt (LB) at the start of the current monitoring period (early 2010).

### Source of data:
Remote sensing data.

### Description of measurement methods and procedures to be applied:
Overlapping 2010 forest cover in Project Area and Leakage Belt with strata boundaries.

### Frequency of monitoring/recording:
Annually.

### Value monitored:
- Low Altitude Forest: 182,132 ha
- Mid Altitude Forest: 108,490 ha

### Monitoring equipment:
ERDAS IMAGINE software for image interpretation and ARC GIS software for mapping and forest cover calculations.

### Calculation method:
Calculation of 2010 forest cover for PA and LB based on 2010 forest cover map established from the satellite image analysis.

### Any comment:
The previous monitoring report assessed the 2010 forest cover as follows (cf. section 3.1):
- Low Altitude Forest: 225,984 ha
- Mid Altitude Forest: 109,109 ha

Differences are due to erroneous image interpretation in the previous analysis and consequently data from the new analysis conducted by PERR-FH has been used (cf. section 4.3.1.1).

---

### Data / Parameter: Regional Forest Cover Monitoring Map 2011

<table>
<thead>
<tr>
<th>Data unit:</th>
<th>ha</th>
</tr>
</thead>
</table>

### Description:
Forest cover in the project area (PA) and in the leakage belt (LB) at the start of the second year of the current monitoring period (early 2011).
**Source of data:**
Remote sensing (two Landsat scenes, historic high-resolution data from Google Earth for ground-truthing)

**Description of measurement methods and procedures to be applied:**
Map accuracy assessed by comparing the final map with ground-truthing data from Google Earth. Minimum map accuracy 90%

**Frequency of monitoring/recording:**
Annually

**Value monitored:**
- PA: 357,842 ha
- LB: 289,174 ha

**Monitoring equipment:**
ERDAS IMAGINE software for image interpretation and ARC GIS software for mapping and forest cover calculations

**Calculation method:**
Calculation of 2011 forest cover for PA and LB based on 2011 forest cover map established from the satellite image analysis

**Data / Parameter:** $A_i$
**Data unit:** Ha

**Description:** Total area of forest stratum i in the project area (PA) at the start of the second year of the current monitoring period (early 2011)

**Source of data:** Remote sensing data

**Description of measurement methods and procedures to be applied:** Overlapping 2011 forest cover in Project Area and Leakage Belt with strata boundaries

**Frequency of monitoring/recording:** Annually

**Value monitored:**
- Low Altitude Forest: 118,877 ha
- Mid Altitude Forest: 238,966 ha

**Measurement methods and procedures applied:**
Calculation of 2011 forest cover for PA and LB based on 2011 forest cover map established from the satellite image analysis

**Any comment:** Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Three strata: Low and mid altitude forest and post-deforestation

**Data / Parameter:** $A_{DefPA,01}$
**Data unit:** ha

**Description:** Area of recorded deforestation in the PA in stratum i during the first year of the current monitoring period (Jan. 01, 2010 – Dec. 31, 2010)

**Source of data:** Remote sensing imagery

**Description of measurement methods and procedures to be applied:** Compare forest cover maps based on subsequent remote sensing imagery to assess change
**Frequency of monitoring/recording:** Annually

**Value monitored:**
- Low Altitude Forest: 154 ha
- Mid Altitude Forest: 97 ha

**Monitoring equipment:** ARC GIS software for mapping and forest cover calculations

**Calculation method:** 2010 forest cover in stratum i in Project Area minus 2011 forest cover in stratum i in Project Area

**Data / Parameter:** $A_{\text{DefLB},i,t}$

**Data unit:** ha

**Description:** Area of recorded deforestation in the LB in stratum i during the first year of the current monitoring period (Jan. 01, 2010 – Dec. 31, 2010)

**Source of data:** Remote sensing imagery

**Description of measurement methods and procedures to be applied:** Compare subsequent remote sensing imagery to assess change

**Frequency of monitoring/recording:** Annually

**Value monitored:**
- Low Altitude Forest: 1,114 ha
- Mid Altitude Forest: 333 ha

**Monitoring equipment:** ARC GIS software for mapping and forest cover calculations

**Calculation method:** 2010 forest cover in stratum i in Leakage Belt minus 2011 forest cover in stratum i in Leakage Belt

**Data / Parameter:** $A_{\text{burn},i,t}$

**Data unit:** Ha

**Description:** Area burned in stratum i during the first year of the current monitoring period (Jan. 01, 2010 – Dec. 31, 2010)

**Source of data:** Burning for deforestation: Landsat remote sensing imagery. Burning in post deforestation land: MODIS/UMD fire alert and monitoring system

**Description of measurement methods and procedures to be applied:** Compare land cover maps based on subsequent remote sensing imagery to assess change

**Frequency of monitoring/recording:** Every five years or prior to any exceptional verification event

**Value monitored:**
- Low Altitude Forest: 154 ha
- Mid Altitude Forest: 97 ha
- Post Deforestation: 50 ha

**Monitoring equipment:** ERDAS IMAGINE software (image analysis) and ARC GIS software (mapping and area estimates)

**Calculation method:** Calculation of area of forest degraded through fire directly in ARC GIS

**Any Comment:** For estimating areas burned in deforested grassland and agricultural land it was assumed that new deforestation represents 50% of cultivated area and that agricultural land is burned every 5 years.

**Data / Parameter:** Regional Forest Cover Monitoring Map 2012

**Data unit:** ha

**Description:** Forest cover in project area (PA) and leakage belt (LB) at the start of the third year of the current monitoring period (early 2012).
**Source of data:** Remote sensing (two Landsat scenes, historic high-resolution data from Google Earth for ground-truthing)

**Description of measurement methods and procedures to be applied:** Map accuracy assessed by comparing the final map with groundtruthing data from Google Earth. Minimum map accuracy 90%

**Frequency of monitoring/recording:** Annually

**Value monitored:**
- PA: 356,957 ha
- LB: 286,247 ha

**Monitoring equipment:** ERDAS IMAGINE software for image interpretation and ARC GIS software for mapping and forest cover calculations

**Calculation method:** Calculation of 2012 forest cover for PA and LB based on 2012 forest cover map established from the satellite image analysis

### Data / Parameter: $A_i$

<table>
<thead>
<tr>
<th>Data unit</th>
<th>Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Total area of forest stratum $i$ in the project area at the start of the third year of the current monitoring period (early 2012)</td>
</tr>
</tbody>
</table>

**Source of data:** Remote sensing data

**Description of measurement methods and procedures to be applied:** Overlapping 2012 forest cover in Project Area and Leakage Belt with strata boundaries

**Frequency of monitoring/recording:** Annually

**Value monitored:**
- Low Altitude Forest: 118,642 ha
- Mid Altitude Forest: 238,316 ha

**Measurement methods and procedures applied:** Overlapping project area map with strata boundaries

**Any comment:** Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Based on preliminary inventories only three strata have been identified: Low and mid altitude forest and post-deforestation

### Data / Parameter: $A_i$

<table>
<thead>
<tr>
<th>Data unit</th>
<th>Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Total area of forest stratum $i$ in the leakage belt at the start of the third year of the current monitoring period (early 2012)</td>
</tr>
</tbody>
</table>

**Source of data:** Remote sensing data

**Description of measurement methods and procedures to be applied:** Overlapping 2012 forest cover in Project Area and Leakage Belt with strata boundaries

**Frequency of monitoring/recording:** Annually

**Value monitored:**
- Low Altitude Forest: 179,402 ha
- Mid Altitude Forest: 106,872 ha

**Measurement methods and procedures applied:** Overlapping project area map with strata boundaries

**Any comment:** Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Based on preliminary inventories only three strata have been identified: Low and mid altitude forest and post-deforestation

### Data / Parameter: $A_{DefPA,ij,t}$

<table>
<thead>
<tr>
<th>Data unit</th>
<th>ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Area of recorded deforestation in the PA in stratum $i$ during the second year of the current monitoring period (Jan. 01, 2011 – Dec. 31, 2011)</td>
</tr>
</tbody>
</table>

**Source of data:** Remote sensing imagery
### Description of measurement methods and procedures to be applied:
Compare forest cover maps based on subsequent remote sensing imagery to assess change.

### Frequency of monitoring/recording:
Annually.

### Value monitored:
- **Low Altitude Forest:** 235 ha
- **Mid Altitude Forest:** 650 ha

### Monitoring equipment:
ARC GIS software for mapping and forest cover calculations.

### Calculation method:
2011 forest cover in stratum i in Project Area minus 2012 forest cover in stratum i in Project Area.

### Data / Parameter: \( A_{\text{DefLB,}i,t} \)

<table>
<thead>
<tr>
<th>Data unit:</th>
<th>ha</th>
</tr>
</thead>
</table>

**Description:** Area of recorded deforestation in the LB in stratum \( i \) during the second year of the current monitoring period (Jan. 01, 2011 – Dec. 31, 2011).

**Source of data:** Remote sensing imagery.

**Description of measurement methods and procedures to be applied:**
Compare subsequent remote sensing imagery to assess change.

**Frequency of monitoring/recording:** Annually.

**Value monitored:**
- **Low Altitude Forest:** 1,615 ha
- **Mid Altitude Forest:** 1,284 ha

**Monitoring equipment:**
ARC GIS software for mapping and forest cover calculations.

**Calculation method:**
2011 forest cover in stratum \( i \) in Leakage Belt minus 2012 forest cover in stratum \( i \) in Leakage Belt.

### Data / Parameter: \( A_{\text{burn,}i,t} \)

<table>
<thead>
<tr>
<th>Data unit:</th>
<th>Ha</th>
</tr>
</thead>
</table>

**Description:** Area burned in stratum \( i \) during the second year of the current monitoring period (Jan. 01, 2011 – Dec. 31, 2011).

**Source of data:**
- Burning for deforestation: Landsat remote sensing imagery.
- Burning in post deforestation land: MODIS/UMD fire alert and monitoring system.

**Description of measurement methods and procedures to be applied:**
Compare land cover maps based on subsequent remote sensing imagery to assess change.

**Frequency of monitoring/recording:** Every five years or prior to any exceptional verification event.

**Value monitored:**
- **Low Altitude Forest:** 235 ha
- **Mid Altitude Forest:** 650 ha
- **Post Deforestation:** 177 ha

**Monitoring equipment:**
ERDAS IMAGINE software (image analysis) and ARC GIS software (mapping and area estimates).

**Calculation method:**
Calculation of area of forest degraded through fire directly in ARC GIS.

**Any Comment:**
For estimating areas burned in deforested grassland and agricultural land it was assumed that new deforestation represents 50% of cultivated area and that agricultural land is burned every 5 years.

### Data / Parameter: Regional Forest Cover Monitoring Map 2013

<table>
<thead>
<tr>
<th>Data unit:</th>
<th>ha</th>
</tr>
</thead>
</table>

**Description:** Forest cover in project area (PA) and leakage belt (LB) at the start of the fourth year of the current monitoring period (early 2013).
### Source of data:
Remote sensing (two Landsat scenes, historic high-resolution data from Google Earth for ground-truthing)

### Description of measurement methods and procedures to be applied:
Map accuracy assessed by comparing the final map with groundtruthing data from Google Earth. Minimum map accuracy 90%

### Frequency of monitoring/recording:
Annually

### Value monitored:
- **PA:** 355,744 ha
- **LB:** 283,038 ha

### Monitoring equipment:
ERDAS IMAGINE software for image interpretation and ARC GIS software for mapping and forest cover calculations

### Calculation method:
Calculation of 2013 forest cover for PA and LB based on 2013 forest cover map established from the satellite image analysis

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A_i )</td>
<td>Total area of forest stratum ( i ) in the project area at the start of the fourth year of the current monitoring period (early 2013)</td>
</tr>
<tr>
<td>Data unit</td>
<td>Ha</td>
</tr>
<tr>
<td>Source of data</td>
<td>Remote sensing data</td>
</tr>
<tr>
<td>Description of measurement methods and procedures to be applied</td>
<td>Overlapping 2013 forest cover in Project Area and Leakage Belt with strata boundaries</td>
</tr>
<tr>
<td>Frequency of monitoring/recording</td>
<td>Annually</td>
</tr>
</tbody>
</table>
| Value monitored | • Low Altitude Forest: 118,196 ha  
• Mid Altitude Forest: 237,548 ha |
| Measurement methods and procedures applied | Overlapping project area map with strata boundaries |
| Any comment | Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Based on preliminary inventories only three strata have been identified: Low and mid altitude forest and post-deforestation |

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A_i )</td>
<td>Total area of forest stratum ( i ) in the leakage belt at the start of the fourth year of the current monitoring period (early 2013)</td>
</tr>
<tr>
<td>Data unit</td>
<td>Ha</td>
</tr>
<tr>
<td>Source of data</td>
<td>Remote sensing data</td>
</tr>
<tr>
<td>Description of measurement methods and procedures to be applied</td>
<td>Overlapping 2013 forest cover in Project Area and Leakage Belt with strata boundaries</td>
</tr>
<tr>
<td>Frequency of monitoring/recording</td>
<td>Annually</td>
</tr>
</tbody>
</table>
| Value monitored | • Low Altitude Forest: 177,257 ha  
• Mid Altitude Forest: 105,781 ha |
| Measurement methods and procedures applied | Overlapping project area map with strata boundaries |
| Any comment | Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Based on preliminary inventories only three strata have been identified: Low and mid altitude forest and post-deforestation |

<table>
<thead>
<tr>
<th>Data / Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A_{DefPA,ij} )</td>
<td>Area of recorded deforestation in the PA in stratum ( i ) during the third year of the current monitoring period (Jan. 01, 2012 – Dec. 31, 2012)</td>
</tr>
<tr>
<td>Data unit</td>
<td>ha</td>
</tr>
<tr>
<td>Source of data</td>
<td>Remote sensing imagery</td>
</tr>
</tbody>
</table>
### Description of measurement methods and procedures to be applied:

Compare forest cover maps based on subsequent remote sensing imagery to assess change.

### Frequency of monitoring/recording:

Annually

### Value monitored:

- **Low Altitude Forest:** 446 ha
- **Mid Altitude Forest:** 767 ha

### Monitoring equipment:

ARC GIS software for mapping and forest cover calculations

### Calculation method:

2012 forest cover in stratum i in Project Area minus 2013 forest cover in stratum i in Project Area

---

**Data / Parameter:** $A_{\text{DefLB, i, t}}$

**Data unit:** ha

**Description:** Area of recorded deforestation in the LB in stratum i during the third year of the current monitoring period (Jan. 01, 2012 – Dec. 31, 2012)

**Source of data:** Remote sensing imagery

**Frequency of monitoring/recording:** Annually

**Value monitored:**
- **Low Altitude Forest:** 2,145 ha
- **Mid Altitude Forest:** 1,091 ha

**Monitoring equipment:** ARC GIS software for mapping and forest cover calculations

**Calculation method:**

2012 forest cover in stratum i in Leakage Belt minus 2013 forest cover in stratum i in Leakage Belt

---

**Data / Parameter:** $A_{\text{burn, i, t}}$

**Data unit:** Ha

**Description:** Area burned in stratum i during the third year of the current monitoring period (Jan. 01, 2012 – Dec. 31, 2012)

**Source of data:**
- Burning for deforestation: Landsat remote sensing imagery.
- Burning in post deforestation land: MODIS/UMD fire alert and monitoring system

**Description of measurement methods and procedures to be applied:** Compare land cover maps based on subsequent remote sensing imagery to assess change

**Frequency of monitoring/recording:** Every five years or prior to any exceptional verification event

**Value monitored:**
- **Low Altitude Forest:** 446 ha
- **Mid Altitude Forest:** 767 ha

**Monitoring equipment:** ERDAS IMAGINE software (image analysis) and ARC GIS software (mapping and area estimates)

**Calculation method:** Calculation of area of forest degraded through fire directly in ARC GIS

**Any Comment:**

For estimating areas burned in deforested grassland and agricultural land it was assumed that new deforestation represents 50% of cultivated area and that agricultural land is burned every 5 years.

---

**Data / Parameter:** Regional Forest Cover Monitoring Map 2014

**Data unit:** ha

**Description:** Forest cover in project area (PA) and leakage belt (LB) at the start of the subsequent monitoring period (early 2014).
### Source of data:
Remote sensing (two Landsat scenes, historic high-resolution data from Google Earth for ground-truthing)

### Description of measurement methods and procedures to be applied:
Map accuracy assessed by comparing the final map with groundtruthing data from Google Earth. Minimum map accuracy 90%

### Frequency of monitoring/recording:
Annually

### Value monitored:
- **PA:** 355,465 ha
- **LB:** 282,468 ha

### Monitoring equipment:
ERDAS IMAGINE software for image interpretation and ARC GIS software for mapping and forest cover calculations

### Calculation method:
Calculation of 2014 forest cover for PA and LB based on 2014 forest cover map established from the satellite image analysis

### Data / Parameter: \( A_i \)
<table>
<thead>
<tr>
<th>Description</th>
<th>Source of data</th>
<th>Measurement methods and procedures to be applied</th>
<th>Frequency of monitoring/recording</th>
<th>Value monitored:</th>
</tr>
</thead>
</table>
| Total area of forest stratum i in the project area at the start of the subsequent monitoring period (early 2014) | Remote sensing data | Overlapping 2014 forest cover in Project Area and Leakage Belt with strata boundaries | Annually          | • Low Altitude Forest: 118,055 ha  
• Mid Altitude Forest: 237,410 ha |

**Any comment:**
Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Based on preliminary inventories only three strata have been identified: Low and mid altitude forest and post-deforestation

### Data / Parameter: \( A_i \)
<table>
<thead>
<tr>
<th>Description</th>
<th>Source of data</th>
<th>Measurement methods and procedures to be applied</th>
<th>Frequency of monitoring/recording</th>
<th>Value monitored:</th>
</tr>
</thead>
</table>
| Total area of forest stratum i in the leakage belt at the start of the subsequent monitoring period (early 2014) | Remote sensing data | Overlapping 2014 forest cover in Project Area and Leakage Belt with strata boundaries | Annually          | • Low Altitude Forest: 176,841 ha  
• Mid Altitude Forest: 106,627 ha |

**Any comment:**
Low altitude forest: 0-800 m; mid altitude forest: 800-1,800 m. Based on preliminary inventories only three strata have been identified: Low and mid altitude forest and post-deforestation

### Data / Parameter: \( A_{DefPA,i,t} \)
<table>
<thead>
<tr>
<th>Description</th>
<th>Source of data</th>
<th>Measurement methods and procedures to be applied</th>
<th>Value monitored:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of recorded deforestation in the PA in stratum i during the fourth year of the current monitoring period (Jan. 01, 2013 – Dec. 31, 2013)</td>
<td>Remote sensing imagery</td>
<td>Overlapping project area map with strata boundaries</td>
<td></td>
</tr>
</tbody>
</table>

**Any comment:**
### Description of measurement methods and procedures to be applied:

Compare forest cover maps based on subsequent remote sensing imagery to assess change.

### Frequency of monitoring/recording:

Annually

### Value monitored:

- **Low Altitude Forest:** 141 ha
- **Mid Altitude Forest:** 138 ha

### Monitoring equipment:

ARC GIS software for mapping and forest cover calculations

### Calculation method:

2013 forest cover in stratum i in Project Area minus 2014 forest cover in stratum i in Project Area

---

### Data / Parameter: $A_{\text{DefLB,}i,t}$

<table>
<thead>
<tr>
<th>Data unit:</th>
<th>ha</th>
</tr>
</thead>
</table>

**Description:** Area of recorded deforestation in the LB in stratum i during the fourth year of the current monitoring period (Jan. 01, 2013 – Dec. 31, 2013)

**Source of data:** Remote sensing imagery

**Description of measurement methods and procedures to be applied:** Compare subsequent remote sensing imagery to assess change.

**Frequency of monitoring/recording:** Annually

**Value monitored:**
- **Low Altitude Forest:** 416 ha
- **Mid Altitude Forest:** 154 ha

**Monitoring equipment:** ARC GIS software for mapping and forest cover calculations

**Calculation method:**

2013 forest cover in stratum i in Leakage Belt minus 2014 forest cover in stratum i in Leakage Belt

---

### Data / Parameter: $A_{\text{burn,}i,t}$

<table>
<thead>
<tr>
<th>Data unit:</th>
<th>Ha</th>
</tr>
</thead>
</table>

**Description:** Area burned in stratum i during the fourth year of the current monitoring period (Jan. 01, 2013 – Dec. 31, 2013)

**Source of data:**
- Burning for deforestation: Landsat remote sensing imagery.
- Burning in post deforestation land: MODIS/UMD fire alert and monitoring system

**Description of measurement methods and procedures to be applied:** Compare land cover maps based on subsequent remote sensing imagery to assess change.

**Frequency of monitoring/recording:** Every five years or prior to any exceptional verification event

**Value monitored:**
- **Low Altitude Forest:** 141 ha
- **Mid Altitude Forest:** 138 ha
- **Post Deforestation:** 56 ha

**Monitoring equipment:**
- ERDAS IMAGINE software (image analysis) and ARC GIS software (mapping and area estimates)

**Calculation method:** Calculation of area of forest degraded through fire directly in ARC GIS

**Any Comment:** For estimating areas burned in deforested grassland and agricultural land it was assumed that new deforestation represents 50% of cultivated area and that agricultural land is burned every 5 years.

---

### Data / Parameter: Degradation PRA results

**Data unit:** -

**Description:** Determination of the potential for forest degradation through wood extraction in the project area
### Description of measurement methods and procedures to be applied:

Through semi-structured interviews, conducted among local communities at main access points to the project area, the PRA determined whether the following activities are occurring in the project area:

- Harvesting of wood for fuel
- Harvesting of wood for charcoal production
- Harvesting of wood for timber
- Harvesting of wood during mining activities

If 10% or more of those interviewed believe that degradation may be occurring, the limited on-the-ground degradation survey will be triggered. A maximum depth of penetration into the forest from access points will be determined for each degradation pressure. If multiple degradation activities occur in the same stratum, the deepest depth of penetration will be used to determine $A_{DEG,i}$.

### Frequency of monitoring/recording:

Every two years, November and December 2012 for the current monitoring report.

### Value monitored:

Less than 10% of those interviewed believe that forest degradation occurs in the project area (cf. 2012 forest degradation analysis report in annex 6).

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>$A_{DEG,i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Ha</td>
</tr>
<tr>
<td>Description:</td>
<td>Area potentially impacted by degradation in the forest stratum $i$</td>
</tr>
<tr>
<td>Source of data:</td>
<td>GIS delineation and field survey</td>
</tr>
</tbody>
</table>

| Description of measurement methods and procedures to be applied: | $A_{DEG}$ will be composed of a buffer from all access points (access buffer), such as roads and rivers or previously cleared areas. The width of the buffer will be determined by the depth of degradation penetration as defined by the degradation PRA |

| Frequency of monitoring/recording: | Determination of $A_{DEG,i}$ will be repeated each time the degradation PRA indicates a potential for degradation in the PA |

### Value monitored:

N/A

Less than 10% of those interviewed during the degradation PRA believe that degradation is occurring inside the project area (Makira Natural Park). In accordance with the M-MON module of the applied methodology, the limited on-the-ground degradation survey was not triggered and no limited Degradation survey had to be conducted.

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>Limited Degradation Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td></td>
</tr>
<tr>
<td>Description:</td>
<td>Quantification of degradation in the forest stratum</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Field measurement</td>
</tr>
</tbody>
</table>

| Description of measurement methods and procedures to be applied: | Degradation through wood extraction will be sampled on several transects of known length and width across the access-buffer area (equal in area to at least 1% of $A_{DEG,i}$) to check whether new tree stumps are evident or not |

| Frequency of monitoring/recording: | The Limited Degradation Survey will be repeated each time the degradation PRA indicates a potential for degradation in the PA |
### Value monitored:

<table>
<thead>
<tr>
<th>Data / Parameter:</th>
<th>A&lt;sub&gt;DEG&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>Ha</td>
</tr>
<tr>
<td>Description:</td>
<td>Total area of degradation sample plots in the forest stratum in the degradation buffer zone</td>
</tr>
<tr>
<td>Source of data:</td>
<td>Field measurement</td>
</tr>
<tr>
<td>Description of measurement methods and procedures to be applied:</td>
<td>Sampling will use plots placed in a systematic grid over the entire degradation buffer zone in order to cover at least 3% of the total area of the buffer zone</td>
</tr>
<tr>
<td>Frequency of monitoring/recording:</td>
<td>Every five years or if the limited degradation survey provides evidence that trees are being removed from the degradation buffer zone (A&lt;sub&gt;DEG&lt;/sub&gt;) determined by the degradation PRA</td>
</tr>
</tbody>
</table>

Less than 10% of those interviewed during the degradation PRA believe that degradation is occurring inside the project area (Makira Natural Park). In accordance with the M-MON module of the applied methodology, the limited on-the-ground degradation survey was not triggered and no limited Degradation survey had to be conducted.
### 3.3 Description of the Monitoring Plan

#### 3.3.1 Carbon pools to be monitored

Only carbon pools included in baseline and project scenario are monitored (cf. section 2.3.3). These pools are presented in table 3.

#### 3.3.2 Monitoring of carbon stocks

In principle, the ex-ante estimated average carbon densities and carbon stock changes should not be significantly changed during the crediting period, as it uses a confident estimation adequate for the project area and because all the forest inside the project area are mature. If carbon stocks in above ground tree biomass should be re-assessed before the end of the first crediting period, the methodology used for the re-sampling will follow the Makira Project SOP developed by Winrock International.

Instead of tracking annual emissions through burning and/or decomposition, the applied methodology employs the simplifying assumption that all carbon stocks are emitted in the year deforested and that no stocks are permanently sequestered (beyond 100 years after deforestation). This assumption applies regardless of whether burning is employed as part of the forest conversion process or as part of post conversion land use activities.

Only at baseline renewal, for each forest and post-deforestation land cover, long-term carbon stocks will be estimated using the same carbon pools and the same inventory methodology as for the initial baseline assessment and applying the following equation:

\[
C_{\text{post},u,i} = C_{\text{AB,tree},i} + C_{\text{BB,tree},i} + C_{\text{NT},i} + C_{\text{DW},i}
\]

Where:

- \( C_{\text{post},u,i} \) = Carbon stock in all pools in post-deforestation land use \( u \) in stratum \( i \); t CO\(_2\)-e/ha
- \( C_{\text{AB,tree},i} \) = Carbon stock in aboveground tree biomass in stratum \( i \); t CO\(_2\)-e/ha
- \( C_{\text{BB,tree},i} \) = Carbon stock in belowground tree biomass in stratum \( i \); t CO\(_2\)-e/ha (below ground biomass fraction from Cairns et al.19974)
- \( C_{\text{NT},i} \) = Carbon stock in non-tree biomass in stratum \( i \); t CO\(_2\)-e/ha

---

The land-use and land cover change (deforestation) monitoring are carried out through remote sensing analysis in the project area, reference areas (RRD and RRL) and leakage belt. Because the type of deforestation occurring in this project area is removal of tree cover from slash and burn agriculture, it is relatively easy to observe changes in forest cover over even short periods of time using satellite imagery. The method for monitoring forest cover change over the project life is the same as the one applied during determination of the project baseline and described in the Makira PD. High-resolution images (e.g., Google Earth data or similar) are acquired for verification of the mapping accuracy.

Based on the remote sensing data outlined above, mapping of deforestation follows the same procedures as the ones outlined in section 2.4.1.1 of the Makira VCS PD. Mapping of deforestation and calculation of the affected areas allows the following:

- At the end of each monitoring period:
  - Calculation of areas deforested during the monitoring period in the project area and the leakage belt.
  - Updating of the benchmark forest maps for the project area and for the leakage belt.
  - Calculation of the remaining area of forest in the RRL ($A_{RRL,forest,i}$).
- At the time of baseline revision (2015 and 2025):
  - Calculation of areas of deforestation in both reference areas (RRD and RRL), the project area and the leakage belt.
  - Updating of forest cover benchmark maps for the reference areas (RRD and RRL), the project area and the leakage belt.
  - Estimation of the total area of deforestation in the RRD ($A_{RRD,unplanned,hyp}$) during the historic reference period and of the deforestation rate.
- As Makira is an area frequently covered with clouds, multiple-date images are used in order to reduce the cloud cover in each point in time below 10%. If the clouded areas in two subsequent points in time do not overlap the deforestation rate is calculated using only the areas not covered by clouds in both points in time. The calculated rate is then applied to the initial forest cover in order to estimate deforestation between the two points in time.

The net carbon stock change as a result of deforestation is equal to the area deforested multiplied by the emission per unit area calculated as follows:

$$\Delta C_{P,DefPA,i,t} = \sum_{n=1}^{U} \left( A_{DefPA,n,i,t} \times \Delta C_{pools,P,Def,n,i,t} \right)$$

$$\Delta C_{P,DefLB,i,t} = \sum_{n=1}^{U} \left( A_{DefLB,n,i,t} \times \Delta C_{pools,P,Def,n,i,t} \right)$$

Where:

$$\Delta C_{P,DefPA,i,t} = \text{Net carbon stock change as a result of deforestation in the project case in the project area in stratum } i \text{ at time } t; \ t \ CO_2-e$$

$$\Delta C_{P,DefLB,i,t} = \text{Net carbon stock change as a result of deforestation in the project case in the leakage belt in stratum } i \text{ at time } t; \ t \ CO_2-e$$
MONITORING REPORT: VCS Version 3

\[ A_{\text{DefPA},u,i,t} = \text{Area of recorded deforestation in the project area stratum } i \text{ converted to land use } u \text{ at time } t; \text{ ha} \]

\[ A_{\text{DefLB},u,i,t} = \text{Area of recorded deforestation in the leakage belt stratum } i \text{ converted to land use } u \text{ at time } t; \text{ ha} \]

\[ \Delta C_{\text{pools,def},u,i,t} = \text{Net carbon stock changes in all pools in the project case in land use } u \text{ in stratum } i \text{ at time } t; \text{ t CO}_2\text{-e/ha} \]

\[ u = 1, 2, 3, \ldots \text{ u post-deforestation land uses} \]

\[ t = 1, 2, 3, \ldots \text{ t years elapsed since the start of the REDD project activity} \]

\[ i = 1, 2, 3, \ldots \text{ M strata} \]

The emissions per unit area are equal to the difference between the stocks before and after deforestation minus any wood products created from timber extraction in the process of deforestation:

\[ \Delta C_{\text{pools,def},t} = C_{\text{BSL},i} - C_{\text{P,post},i} - C_{\text{wp},i} \]

Where:

\[ \Delta C_{\text{pools,def},t} = \text{Net carbon stock changes in all pools as a result of deforestation in the project case in land use } u \text{ in stratum } i \text{ at time } t; \text{ t CO}_2\text{-e/ha} \]

\[ C_{\text{BSL},i} = \text{Carbon stock in all pools in the baseline case in stratum } i; \text{ t CO}_2\text{-e/ha} \]

\[ C_{\text{P,post},i} = \text{Carbon stock in all pools in post-deforest. land use } u \text{ in stratum } i; \text{ t CO}_2\text{-e/ha} \]

\[ C_{\text{wp},i} = \text{Carbon stock sequestered in wood products from harvests in stratum } i; \text{ t CO}_2\text{-e/ha} \]

\[ u = 1, 2, 3, \ldots \text{ u post-deforestation land uses} \]

\[ t = 1, 2, 3, \ldots \text{ t years elapsed since the start of the REDD project activity} \]

\[ i = 1, 2, 3, \ldots \text{ M strata} \]

As mentioned above, carbon stocks in long-term wood products are not considered significant in the case of the Makira project and therefore \( C_{\text{wp},i} \) is accounted as zero.

3.3.4 Monitoring of forest degradation through wood extraction

In the case of the Makira project, the following two types of forest degradation through wood extraction have to be distinguished:

- Forest degradation from harvesting wood for timber and for fuel.
- Forest degradation through natural disturbances.

3.3.4.1 Monitoring extraction of wood for timber and fuel

Although forest degradation from wood extraction is considered insignificant in the case of Makira and has therefore not been included in the baseline, emissions from forest degradation caused by the extraction of wood for timber and for fuel are monitored using guidance from the M-MON module of the applied methodology.

The monitoring method provides estimates for any emissions from forest degradation that may occur in the project area (\( \Delta C_{\text{P,Deg},i,t} \)). This degradation, and thus reduction of forest carbon stocks, will result from either illegal extraction of trees for timber or for fuel and charcoal. As remote methods are not yet capable of measuring biomass stocks and stock changes, a ground-based method proposed by the applied methodology is used.

Based on the M-MON module of the applied methodology, the following steps are implemented to estimate emissions related to forest degradation from extraction of wood for timber and fuel:
In order to determine if there is the potential for illegal extraction of trees to occur, a participatory rural appraisal (PRA) of the communities inside and surrounding the project area is completed every 2 years. An output of the PRA is the distance of degradation penetration from all access points (access buffer), such as roads and rivers or previously cleared areas, to the project area. If this assessment finds no potential pressure for these activities degradation (\(\Delta C_{P,\text{Deg},i,t}\)) is assumed to be zero and no further monitoring of forest degradation will occur.

If the results of the PRA suggest that there is a potential for degradation activities, then limited field sampling is carried out:

- The area subject to degradation is delineated (\(A_{\text{Deg},i}\)) based on the access buffer from all access points, such as roads or previously cleared areas, to the project area, with a width equal to the distance of degradation penetration.
- \(A_{\text{Deg},i}\) is then sampled by surveying several transects of known length and width across the access-buffer area (equal in area to at least 1% of \(A_{\text{Deg},i}\)) to check whether new tree stumps are evident or not. If there is little to no evidence that trees are being harvested then degradation will be assumed to be zero and no further monitoring is triggered.

If the limited sampling does provide evidence that trees are being removed in the buffer area, then a more systematic sampling has to be implemented:

- The sampling plan must be designed using plots systematically placed over the buffer zone so that they sample at least 3% of the area of the buffer zone (\(A_{\text{Deg},i}\)).
- The diameter of all tree stumps is measured and conservatively assumed to be the same as the DBH. If the stump is a large buttress, several individuals of the same species are identified nearby in order to determine a ratio of the diameter at DBH to the diameter of buttress at the same height aboveground as the measured stumps. This ratio is then applied to the measured stumps to estimate the likely DBH of the cut tree.
- The above-and belowground carbon stock of each harvested tree are estimated using the same allometric regression equation and root to shoot ratio used for estimating the carbon pool in trees in the baseline scenario (cf. section 2.4.2). The mean above- and belowground carbon stock of the harvested trees is conservatively estimated to be the total emissions and to all enter the atmosphere.
- If species cannot be identified from stumps then it is assumed that the harvested species is the species most commonly harvested for the specific degradation purpose. A PRA will be used to determine the most commonly harvested species.

Carbon stock changes from forest degradation are estimated using the following equation:

\[
\Delta C_{P,\text{Deg},i,t} = A_{\text{Deg},i} \times \frac{C_{\text{Deg},i,t}}{AP_i}
\]

Where:

- \(\Delta C_{P,\text{Deg},i,t}\) = Net carbon stock changes as a result of degradation in stratum \(i\) in the project area at time \(t\); t CO₂-e
- \(A_{\text{Deg},i}\) = Area potentially impacted by degradation processes in stratum \(i\); ha
- \(C_{\text{Deg},i,t}\) = Biomass carbon of trees cut and removed through degradation process from plots measured in stratum \(i\) at time \(t\); t CO₂-e
- \(AP_i\) = Total area of degradation sample plots in stratum \(i\); ha
- \(i\) = 1, 2, 3, ... M strata
- \(t\) = 1, 2, 3, ... \(t\) years elapsed since the start of the REDD project activity
3.3.4.2 Monitoring areas undergoing natural disturbances

Where natural disturbances occur ex-post in the project area such as tectonic activity (earthquake, landslide, volcano), extreme weather events (cyclones, extreme rain, etc.), pest, drought, or fire that result in a degradation of forest carbon stocks, the area disturbed is delineated and the resulting emissions estimated. Emissions resulting from natural disturbances may be omitted if they are deemed de minimis through the use of the module T-SIG. The net carbon stock change as a result of the disturbance is equal to the area disturbed multiplied by the emission per unit area. In situations where the impact of disturbances on forest carbon stocks in a stratum varies spatially, the stratum may be further stratified based on post-natural disturbance carbon stocks. Where this occurs, such stratification by carbon stocks are maintained for the project life.

If the disturbance event occurs ex-post in the project area, the area disturbed is delineated and the area of each post-disturbance stratum must be delineated. The area disturbed in the with-project scenario is tracked directly using the remote sensing techniques described in section 4.3.2 of the monitoring plan. For unplanned deforestation as in the case of the Makira project, the total area to be considered in the project area ($A_{\text{DisPA,q,i,t}}$) is equal to the area of overlap between the delineated area of the disturbance and the summed area of unplanned deforestation in the project area ($A_{\text{BSL,PA,unplanned,t}}$), summed to the year in which the disturbance occurred.

Where the natural disturbance that took place in post-natural disturbance stratum $q$ included fire, the area burned is assumed to be equal to the area impacted by natural disturbance in post-natural disturbance stratum $q$. Therefore:

$$A_{\text{burn,i,t}} = \sum_{q=1}^{Q} A_{\text{burnq,i,t}}$$

$$A_{\text{burn,q,i,t}} = A_{\text{DisPA,q,i,t}}$$

for stratum where the natural disturbance included fire

Where:

- $A_{\text{DisPA,q,i,t}}$ = Area impacted by natural disturbance in post-natural disturbance stratum $q$ in stratum $i$, at time $t$, ha
- $A_{\text{burn,q,i,t}}$ = Area burnt in post-natural disturbance stratum $q$ in stratum $i$, at time $t$, ha
- $q$ = 1, 2, 3, ... $Q$ post-natural disturbance strata where the natural disturbance included fire
- $i$ = 1, 2, 3, ... $M$ strata
- $t$ = 1, 2, 3, ... $T$ years elapsed since the start of the REDD project activity

Emissions from any fires are calculated using the E-BB module of the applied methodology and included in Section 4.3.6 “Monitoring project GHG emissions”. The emission per unit area is equal to the difference between the stocks before and the stocks after the natural disturbance minus any wood products created from timber extraction following the natural disturbance:

$$\Delta C_{P,\text{Dist,q,i,t}} = C_{BSL,i} - C_{P,\text{Dist,q,i}} - C_{WP,q,i}$$

Where:

- $\Delta C_{P,\text{Dist,q,i,t}}$ = Net carbon stock changes in pools as a result of natural disturbance in the project case in post-natural disturbance stratum $q$ in stratum $i$ at time $t$, tCO$_2$-e/ha
- $C_{BSL,i}$ = Carbon stock in all pools in the baseline case in stratum $i$, tCO$_2$-e/ha
- $C_{P,\text{Dist,q,i}}$ = Carbon stock in pools in post-natural disturbance strata $q$ in stratum $i$, tCO$_2$-e/ha
- $C_{WP,q,i}$ = Carbon stock sequestered in wood products from harvests following natural disturbance in post-natural disturbance stratum $q$, in stratum $i$, tCO$_2$-e/ha
For calculation of carbon stock sequestered in wood products, the CP-W module of the applied methodology is used. It is conservative in the project case to assume no wood products are produced. Instead of tracking annual emissions through burning and/or decomposition, the applied methodology employs the simplifying assumption that all carbon stocks are emitted in the year the natural disturbance occurs and that no stocks are permanently sequestered (beyond 100 years after deforestation).

For each post-natural disturbance stratum (q), the carbon stock following the natural disturbance is estimated. Carbon stocks are measured and estimated using the methods given in modules CP-AB, CP-D, CP-L, and CP-S of the applied methodology. The uncertainty in carbon stock estimates and resulting emissions is included in the estimation of with-project scenario uncertainty calculations performed using the module X-UNC during each verification event unless indisputably conservative estimates are used.

Where the natural disturbance does not result in the conversion of forest to non-forest land cover and where the land use does not change as a result of the natural disturbance, soil carbon stocks following the natural disturbance are assumed to equal baseline soil carbon stocks ($C_{SOC,BSL,i}$ = $C_{SOC,q,i}$). Where the natural disturbance does result in the conversion of forest to non-forest land cover, the mean post-natural disturbance soil organic is assumed to equal post-deforestation soil organic carbon and estimated using the methods given in the module CP-S.

$$C_{P,Dist,q,i,t} = C_{AB,tree,i} + C_{BB,tree,i} + C_{AB,non-tree,i} + C_{BB,non-tree,i} + C_{DW,i} + C_{LI,i} + C_{SOC,i}$$

Where:

- $C_{P,Dist,q,i,t}$ = Carbon stock in all pools in post-nat. disturbance q in baseline stratum i; tCO$_2$-e/ha
- $C_{AB,tree,i}$ = Carbon stock in aboveground tree biomass in stratum i; tCO$_2$-e/ha
- $C_{BB,tree,i}$ = Carbon stock in belowground tree biomass in stratum i; tCO$_2$-e/ha
- $C_{AB,non-tree,i}$ = Carbon stock in aboveground non-tree vegetation in stratum i; tCO$_2$-e/ha
- $C_{BB,non-tree,i}$ = Carbon stock in belowground non-tree vegetation in stratum i; tCO$_2$-e/ha
- $C_{DW,i}$ = Carbon stock in dead wood in stratum i; tCO$_2$-e/ha
- $C_{LI,i}$ = Carbon stock in litter in stratum i; tCO$_2$-e/ha
- $C_{SOC,i}$ = Mean stock in soil organic carbon in stratum i; tCO$_2$-e/ha
- q = 1, 2, 3, … Q post-natural disturbance strata
- i = 1, 2, 3, … M strata

Carbon pools excluded from the project are accounted as zero. For the determination which carbon pools must be included in the calculations as a minimum, Tool T-SIG is used.

### 3.3.5 Monitoring carbon stock enhancements

No areas expected to be deforested in the baseline and assumed to accumulate carbon have been identified in the Makira project. Consequently carbon stock enhancements are not monitored.

### 3.3.6 Monitoring project GHG emissions

Where significant, non-CO$_2$ greenhouse gas emissions occurring within the project boundary must be evaluated. For example, where deforestation or degradation occurs within the project boundaries or in
the leakage belt and fire is used as a means of forest clearance, the non-CO₂ emissions may be significant. For determining which emissions must be included in the calculations as a minimum, the "Tool for testing significance of GHG emissions in A/R CDM project activities" is used. Emissions are calculated through applying the modules E-BB, E-FCC and E-NA of the applied methodology. Project emissions are estimated using the following equation:

\[
GHG_{P,E,i,t} = E_{FC,i,t} + E_{\text{BiomassBurn},i,t} + N_2O_{\text{direct-N},i,t}
\]

Where:

- \(GHG_{P,E,i,t}\) = Greenhouse gas emissions as a result of deforestation activities within the project area in the project case in stratum \(i\) in year \(t\); t CO₂-e
- \(E_{FC,i,t}\) = Emission from fossil fuel combustion in stratum \(i\) within the project area in year \(t\); t CO₂-e
- \(E_{\text{BiomassBurn},i,t}\) = Non-CO₂ emissions due to biomass burning in stratum \(i\) in year \(t\); t CO₂-e
- \(N_2O_{\text{direct-N},i,t}\) = Direct N₂O emission as a result of nitrogen application on the alternative land use in stratum \(i\) within the project area in year \(t\); t CO₂-e

\(t\) = 1, 2, 3, … t years elapsed since the start of the REDD project activity

\(i\) = 1, 2, 3, … M strata

As demonstrated in section 2.3.4 of the Makira Project Description, the Makira project operates two cars (Toyota 4x4) that do not exceed 100 km per month due to the limited road infrastructure on site, seven 125cc motorcycles, and one metal boat with a 25hp outboard engine. Also, the Makira Project does not intend to promote livestock production nor make any use of chemical materials and fertilizers in promoting improved agricultural practices. Project emissions from fossil fuel consumption and from nitrogen application are therefore considered insignificant and accounted as zero and are not monitored.

Consequently, the only project emissions monitored in the Makira project are emissions from biomass burning using the E-BB module of the applied methodology. If fire is used to clear the land or constitutes a cause of forest degradation, emissions of CO₂, N₂O and CH₄ result. The E-BB module of the applied methodology considers the following types of fire:

- Conversion of forest land to non-forest land using fire.
- Periodical burning of grassland or agricultural land after deforestation.
- Burning in forest land remaining forest land.

### 3.3.6.1 Conversion of forest land to non-forest land using fire

In the case of the Makira project, CO₂ emissions from conversion of forest land to non-forest land using fire are accounted for as carbon stock changes and are thus also monitored as such through the monitoring of deforestation. Non-CO₂ emissions from fires are not included in the baseline, but if fires occur ex-post in the project they are monitored if they are significant. In this case, the area burned per stratum (\(A_{\text{burn}}\)) is equal to the area deforested per stratum in the project area during the monitoring period (cf. section 4.3.2).

In accordance with the E-BB module of the applied methodology and based on the IPCC 2006 Inventory Guidelines, greenhouse gas emissions from converting forests to non-forests by fire are estimated as follows:

\[
E_{\text{BiomassBurn},t} = \sum_{g=1}^{G} \left( (A_{\text{burn},i,t} \ast B_{ij} \ast COMF_i \ast G_{d,j} \ast 10^{-3}) \ast GWP_g \right)
\]
Where:

\[ E_{\text{Burn},i,t} = \text{Greenhouse emissions due to biomass burning as part of deforestation activities in stratum } i \text{ in year } t; \text{tCO}_2\text{-e of each GHG (CH}_4, \text{N}_2\text{O)} \]

\[ A_{\text{Burn},i,t} = \text{Area burnt for stratum } i \text{ at time } t; \text{ ha} \]

\[ B_{i,t} = \text{Average aboveground biomass stock before burning stratum } i, \text{ time } t; \text{ tons d.m./ha} \]

\[ COMF_i = \text{Combustion factor for stratum } i; \text{ dimensionless (see annex 1 for default values as derived from Table 2.6 of IPCC, 2006)} \]

\[ G_{g,i} = \text{Emission factor for stratum } i \text{ for gas } g; \text{ kg/t dry matter burnt (see section III and annex 2 for default values as derived from Table 2.5 of IPCC, 2006)} \]

\[ GWP_g = \text{Global warming potential for gas } g; \text{ t CO}_2\text{/t gas } g \text{ (default values from IPCC SAR: CH}_4 = 21; \text{N}_2\text{O} = 310) \]

\[ g = 1, 2, 3 \ldots \text{ G greenhouse gases (to include methane and nitrous oxide)} \]

\[ t = 1, 2, 3, \ldots \text{ t years elapsed since the start of the REDD project activity} \]

\[ i = 1, 2, 3, \ldots \text{ M strata} \]

The following default values are used by the Makira project:

\[ COMF_i = 0.50 \text{ for primary tropical moist forest; dimensionless (from annex 1 of the E-BB module of the applied methodology)} \]

\[ G_{g,i} = 4.7 \text{ for CH}_4 \text{ and 0.26 for N}_2\text{O in tropical forests; kg/t d.m. burnt (from annex 2 of the E-BB module of the applied methodology)} \]

\[ GWP_g = 21 \text{ t CO}_2\text{/t gas for CH}_4 \text{ and 310 t CO}_2\text{/t gas for N}_2\text{O} \]

Average aboveground biomass stocks before burning for a particular stratum are estimated based on the results of the carbon stock analysis presented above but without considering the below ground biomass pool with the following equation:

\[ B_{i,t} = (C_{\text{AB},i,t} + C_{\text{DW},i,t}) \times \frac{12}{44} \times \frac{1}{\text{CF}} \]

Where:

\[ B_{i,t} = \text{Average aboveground biomass stock before burning stratum } i, \text{ time } t; \text{ tons d.m./ha} \]

\[ C_{\text{AB},i,t} = \text{Mean aboveground biomass carbon stock in stratum } i \text{ at time } t; \text{ t CO}_2\text{-e/ha} \]

\[ C_{\text{DW},i,t} = \text{Carbon stock in dead wood for stratum } i, \text{ at time } t; \text{ t CO}_2\text{-e/ha (cf. annex 1)} \]

\[ \frac{12}{44} = \text{Inverse ratio of molecular weight of CO}_2 \text{ to carbon, t CO}_2\text{-e/t C} \]

\[ \text{CF} = \text{Carbon fraction of biomass; t C/t d.m. (default carbon fraction of biomass is 0.47 t C/t d.m.}} \]

\[ t = 1, 2, 3, \ldots \text{ t years elapsed since the start of the REDD project activity} \]

\[ i = 1, 2, 3, \ldots \text{ M strata} \]

3.3.6.2 Burning in forest land remaining forest land:

Biomass burning inside forests remaining forest, for example for regenerating forest pastures, is not a practice observed in or around the Makira protected area and therefore considered non significant and is not monitored. However, fires occurring inside natural forests can also be monitored using the MODIS based system developed by the University of Maryland presented in the previous section. As this system is used for monitoring periodic fires in grassland and agricultural lands after deforestation, emissions from burning inside forests could also be taken into account during monitoring if they appear to be significant.
3.3.7 Responsibilities

General responsibility for monitoring of the Makira project lies with the head office of the WCS Madagascar country program in Antananarivo and particularly WCS Madagascar’s Climate Change Technical Assistant (CCTA). More specifically, responsibilities for carrying out the different monitoring activities, as set out in the monitoring plan above, will be as follows:

- **Monitoring carbon stocks:**
  
  As set out above, carbon stocks in the different carbon pools considered by the Makira project will be monitored only for baseline renewal at the end of each 10-year baseline period (2014 and 2024) or in the case of an exceptional renewal of the baseline. Monitoring carbon stocks in the areas concerned by deforestation will be under the responsibility of the CCTA based at WCS head office in Antananarivo. Based on guidance provided in the relevant modules of the applied methodology, the CCTA will develop the inventory design and relevant instructions for the field teams. Field work itself will be conducted by the WCS inventory team at the office in Maroantsetra which has already been trained in forest carbon stock inventory techniques for the initial carbon stock inventory conducted for establishing the initial baseline of the Makira project, or by specialised national consulting firms. After the fieldwork, inventory data will be transferred to the CCTA for data analysis and interpretation and integration into the renewed baseline.

- **Monitoring land use and land cover change:**
  
  Land use and land cover changes, particularly annual areas of unplanned deforestation in the project area and in the leakage belt, will be monitored at the end of each 5-year monitoring period (2009, 2014, 2019, 2024, 2029 and 2034) or for any exceptional monitoring event. Monitoring deforestation in the project area and in the leakage belt will be the responsibility of the WCS GIS and remote sensing unit in the head office in Antananarivo, under the supervision of WCS Madagascar’s CCTA. Monitoring of deforestation will be carried out using the same methodologies used for the establishment of the initial baseline in 2005. Analysis of deforestation during the monitoring period will be subcontracted to specialised consulting firms and supervised by the GIS unit. Forest cover and deforestation mapping for each monitoring period, as well as deforestation modelling and deforestation projections for baseline renewal (in 2014 and 2024 or for exceptional baseline renewal) will be carried out directly by WCS Madagascar’s GIS unit with technical support from WCS International’s Programme Support unit in New York. All remote sensing data such as satellite images acquired for deforestation analysis as well as shapefiles of the developed forest cover, deforestation and deforestation projection maps will be stored in the same Makira specific database mentioned above. All data will be preserved at least until the end of the project period in 2034.

- **Monitoring forest degradation:**
  
  Responsibilities for monitoring forest degradation from wood extraction, through mining and from natural disturbances are defined as follows:

  - **Monitoring forest degradation from illegal wood extraction** for fuel or for timber is under the responsibility of the CCTA. He will regularly work with the field team in Maroantsetra in order to assess the potential for illegal logging activities in the project area based on guidance provided by the applied methodology. If the degradation PRA shows a potential for
forest degradation through wood extraction he will initiate with the field team a limited
degradation survey in order to quantify degradation in the forest stratum. Original field data
from the PRA will be stored at the Maroantsetra office for at least the current monitoring
period. PRA and survey results in electronic form will be preserved in the Makira database at
least until the start of the subsequent baseline period.

- **Monitoring forest degradation through illegal mining** will be conducted by the GIS team
  in Antananarivo, using remote sensing data acquired for monitoring deforestation and
  following the methodology presented above. Results of the analysis will be preserved in the
  Makira database at least until the start of the next baseline period.

- **Monitoring forest degradation through natural disturbances** is under the responsibility
  of the CCTA and will only be conducted if exceptional natural disturbances have occurred
during the monitoring period. Specific monitoring activities will be carried out by the WCS
  GIS unit for remote sensing matters and by the WCS Maroantsetra team if fieldwork is
  required. Data produced will be preserved in the Makira specific database at least until the
  start of the subsequent baseline period.

• **Monitoring project GHG emissions**
  As mentioned above, project GHG emissions from fossil fuel consumption are considered
  insignificant and will not be monitored. Non-CO₂ emissions from using fire for deforestation
  activities will be monitored as part of the deforestation monitoring process under the
  responsibility of the CCTA. Emissions from burning in forests remaining forests and from
  periodical burning of grassland and agricultural land after deforestation will be monitored based
  on remote sensing data provided by the MODIS/UMD fire monitoring and alert system
  described above by the GIS team under the supervision of the CCTA. Remote sensing data and
  analysis results will be stored in the Makira database and preserved at least until the start of the
  next monitoring period.

3.3.8 **Documentation**

A consistent time-series of data on land-use change, and emissions and removals of CO₂ must
emerge from periodic monitoring. This is only possible if a consistent methodology is applied over
time. The methodological procedures used must be documented, in particular, the following
information will be provided when remotely sensed data are used:

- **Data sources and pre-processing:**
  Type, resolution, source and acquisition date of the remotely sensed data (and other data)
  used; geometric, radiometric and other corrections performed, if any; spectral bands and
  indexes used (such as NDVI); projection and parameters used to geo-reference the images;
  error estimate of the geometric correction; software and software version used to perform tasks;
  etc.

- **Data classification:**
  Definition of the classes and categories; classification approach and classification algorithms;
  coordinates and description of the ground-truth data collected for training purposes; ancillary
  data used in the classification, if any; software and software version used to perform the
  classification; additional spatial data and analysis used for post-classification analysis, including
  class subdivisions using non-spectral criteria, if any; etc.

- **Classification accuracy assessment:**
  Accuracy assessment technique used; coordinates and description of the ground-truth data
  collected for classification accuracy assessment; and final classification accuracy assessment.

- **Changes in Data sources and pre-processing / Data classification:**
If in subsequent periods changes will be made to the original data or use of data each change and its justification will be explained and recorded; and when data from new satellites are used documentation will follow the above

• **Data Management and storage:**

A schematical presentation of the management and storage of GIS data from the Makira project is presented in annex 11 of the Makira VCS Project Description.

The Government of Madagascar is the clear and uncontested owner of the land on which the Makira Project activities takes place. Consequently the Government of Madagascar is the sole and exclusive owner of the carbon credits generated by the Makira Project (see section 2.1.5). The Government contracted the Makira Carbon Company (MCC) as its exclusive agent to sell these carbon credits; any transaction made by the MCC has to first receive the approval of the Government. The agreement also stipulates that the State will not directly market, sell, distribute, promote, advertise or otherwise deal with the Makira carbon credits; nor will it enter into any agreement with any party (other than the MCC) which confers upon such party the rights to do the same. Therefore, there is no risk that Makira carbon credits will be sold by another entity.

The project will be validated and verified under the VCS and CCBA standard. It will be listed in the CCBA Project database and the VCS Project database. Any VCU's generated will be recorded in one of the official VCS registry systems (i.e. Markit).

In addition, the agreement between the Government of Madagascar and the MCC stipulates that an internal registry of the Makira carbon credits will be maintained. The registry will contain: (i) the name of each purchaser of the VCU's generated by Makira; (ii) the number of VCU's purchased by each such purchaser (expressed in metric tons of CO$_2$ equivalent generated during a designated time period); (iii) the period in which the VCU's were generated; (iv) the price paid by each purchaser for the purchase; and (v) a copy of the purchase agreement relating to each purchase. The registry may be maintained by a third party agent and will be made available to the Government for inspection and copying from time to time upon request.
4 QUANTIFICATION OF EMISSION REDUCTIONS AND REMOVALS

4.1 Carbon pools and stocks
In accordance with the M-MON module of the applied methodology, carbon stocks in the identified forest and post deforestation strata (cf. carbon stock inventory in annex 2) are only reviewed every 10 years for baseline renewal. Consequently, forest and post deforestation carbon stocks from the Makira project description have been used for estimating carbon stock changes through unplanned deforestation during the 2010 to 2013 monitoring period (cf. table 3 on page 39 and table 4 below).

4.2 Baseline Emissions
This is the second monitoring report of the Makira project under the VCS, valid for years 6, 7, 8 and 9 of the project crediting period. Following the applied methodology the baseline has to be updated every ten years only and therefore the baseline from the 2012 Makira PD can be used. Only emissions from carbon stock changes due to deforestation are considered in the baseline. Emissions from forest degradation and project implementation are conservatively excluded from the baseline.

4.2.1 Baseline deforestation
Estimation of annual areas of unplanned deforestation in the project area under the without project scenario has been implemented by applying the following four steps:

- Estimation of the annual areas of unplanned baseline deforestation in the Reference area for deforestation (RRD).
- Estimation of the annual areas of unplanned baseline deforestation in the project area (PA).
- Analysis of deforestation constraints.

The entire process is detailed in section 2.4 of the Makira project description. Results for the 2010 to 2013 monitoring period are presented in tables 5 and 6 on the following page.

Table 4: Average carbon stocks and 95% confidence intervals in tCO$_2$-e/ha for two forest strata and one post-deforestation stratum

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Average carbon stocks and 95% Confidence Interval in t CO$_2$-e/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$C_{AB\text{,tree}}$</td>
</tr>
<tr>
<td></td>
<td>AV</td>
</tr>
<tr>
<td>Forest Stratum 1: Low Altitude</td>
<td>391.78</td>
</tr>
<tr>
<td>Forest Stratum 2: Mid Altitude</td>
<td>609.59</td>
</tr>
<tr>
<td>Post Deforestation</td>
<td>177.51</td>
</tr>
</tbody>
</table>

$C_{BSL,i}$ = Carbon stock in all carbon pools in forest stratum $i$; t CO$_2$-e/ha
$C_{AB\text{,tree},i}$ = Carbon stock in aboveground tree biomass in stratum $i$; t CO$_2$-e/ha
$C_{BB\text{,tree},i}$ = Carbon stock in belowground tree biomass in stratum $i$; t CO$_2$-e/ha
$C_{DW,i}$ = Carbon stock in dead wood in stratum $i$; t CO$_2$-e/ha
$C_{NT,i}$ = Carbon stock in non-tree biomass in stratum $i$; t CO$_2$-e/ha
Baseline carbon stock changes from deforestation

Baseline emissions from carbon stock changes through deforestation in the project area and in the leakage belt during the 2010 to 2013 monitoring period were estimated based on the BL-UP module of the applied methodology. Carbon stock changes can be estimated based on estimated areas of unplanned baseline deforestation and carbon stocks in forest and post-deforestation strata. For the present monitoring report, these numbers could be taken directly from the PDD for the 5 years of the monitoring period. Tables 5 and 6 present the annual areas of baseline deforestation in the project area and in the leakage belt, while carbon stocks are presented in table 4 above. More detail on this process is provided in sections 2.4 (baseline deforestation) and 3.1 (emissions from baseline carbon stock changes) of the Makira project description.

The sum of baseline carbon stock changes from deforestation was estimated using the following equations provided by the applied methodology:

\[ \Delta C_{TOT} = C_{BSL} - C_{post} - C_{wp} \]

\[ C_{BSL} = \sum_{i=1}^{r} \sum_{j=1}^{M} (C_{BSL,ij}) \times A_{unplanned,ij} \]
\[ C_{post} = \sum_{i=1}^{t} \sum_{i=1}^{M} (C_{post,i} \times A_{unplanned,i,t}) \]
\[ C_{wp} = \sum_{i=1}^{t} \sum_{i=1}^{M} (C_{WP,i} \times A_{unplanned,i,t}) \]

Where:
- \( \Delta C_{TOT} \) = Sum of the baseline carbon stock change in all pools up to time \( t^* \); t CO\(_2\)-e (calculated separately for the project area [PA] and the leakage belt [LB])
- \( C_{BSL} \) = Total forest carbon stock in areas deforested in the baseline case; t CO\(_2\)-e
- \( C_{post} \) = Total post-deforestation carbon stock in areas deforested; t CO\(_2\)-e
- \( C_{wp} \) = Total carbon stock in harvested wood products; t CO\(_2\)-e
- \( C_{BSL,i} \) = Carbon stock in all carbon pools in the forest stratum \( i \); t CO\(_2\)-e/ha
- \( A_{unplanned,i,t} \) = Area of unplanned deforestation in forest stratum \( i \) at time \( t \); ha
- \( C_{post,i} \) = Carbon stock in all carbon pools in the post-deforestation stratum \( i \); t CO\(_2\)-e/ha
- \( C_{WP,i} \) = Mean carbon stock in wood products pool (stock remaining in wood products after 100 years) from stratum \( i \); t CO\(_2\)-e ha\(^{-1}\)
- \( t \) = 1, 2, 3, … \( t \) years elapsed since the projected start of the REDD project activity
- \( i \) = 1, 2, 3, … \( M \) strata

As demonstrated in the Makira project description and presented in table 3, the long-term wood products pool is considered insignificant in the case of the Makira project and was accounted as zero. Consequently, total baseline carbon stock changes were estimated by subtracting total post-deforestation carbon stocks from the total carbon stocks of forest areas that were expected to be deforested under the baseline scenario. Calculations were conducted separately for project area and leakage belt and results are presented in table 7. More detail on baseline emissions for the first monitoring period can be found in the “Makira Monitoring” Excel file. As other greenhouse gas emissions (fossil fuel combustion, etc) have been conservatively excluded from the baseline, total baseline greenhouse gas emissions of the Makira project are equal to the total carbon stock changes from deforestation presented in table 7.

<table>
<thead>
<tr>
<th>Year</th>
<th>Baseline Emissions from Carbon Stock Changes [t CO(_2)-e]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Project area</td>
</tr>
<tr>
<td>2010</td>
<td>599,838</td>
</tr>
<tr>
<td>2011</td>
<td>631,609</td>
</tr>
<tr>
<td>2012</td>
<td>663,381</td>
</tr>
<tr>
<td>2013</td>
<td>695,153</td>
</tr>
<tr>
<td>Total</td>
<td>2,589,981</td>
</tr>
</tbody>
</table>
4.3 Project Emissions

Project emissions are the greenhouse gas emissions under the project scenario that really occurred during the monitoring period. While they have been estimated ex-ante in the project description they could be measures ex-post for the present monitoring report. In accordance with the applied methodology, the following emission sources have been considered under the project scenario:

- Emissions from deforestation
- Emissions from forest degradation (through wood extraction)
- Emissions from project implementation

4.3.1 Emissions from deforestation

Emissions from unplanned deforestation in the project case can be estimated in a similar way as presented for baseline emissions above by estimating the carbon stock difference in the project area and in the leakage belt at the beginning and at the end of the monitoring period. In accordance with the applied methodology, this was achieved in the following three steps:

- Estimation of areas of unplanned deforestation during the 2010 to 2013 monitoring period
- Estimation of forest and post deforestation carbon stocks
- Estimation of total carbon stock changes

4.3.1.1 Annual areas of unplanned deforestation in the project case

The land-use and land cover change (deforestation) monitoring for the 2010 to 2013 monitoring period was carried out through remote sensing analysis in the project area, and in the leakage belt. Because the type of deforestation occurring in the project area is removal of tree cover by slash and burn agriculture, it was relatively easy to observe changes in forest cover over even short periods of time using satellite imagery.

Unlike for the previous monitoring period (2005 to 2009), for the current monitoring period areas of unplanned deforestation have been assessed separately for each year (2010, 2011, 2012 and 2013). However, the method for monitoring forest cover change over the project life was the same as the one applied for determining the project baseline for developing benchmark forest and baseline deforestation maps detailed in section 2.4 of the Makira project description and for the previous 2005 to 2010 Makira monitoring report. It was based on a series of medium resolution Landsat 5 and 7 satellite images of two scenes (158/070 and 158/071) covering the project area and the leakage belt at the start of each year of the monitoring period, as well as the start of the next monitoring period.

The only difference was the use of the Random Forest Algorithm for classification of the training parcels to replace the maximum likelihood method used during baseline establishment and the first monitoring report. This change seemed appropriate as recent deforestation analysis conducted by the PHCF and PERR-FH projects have demonstrated the superior quality of images analyzed using this new algorithm (cf. deforestation analysis report in annex 1. The deforestation analysis report did not cover the year 2010. For the situation in 2010 the recent analysis of deforestation in the humid forest eco-region conducted by the PERR-FH project was used. This was possible because the PERR-FH project used exactly the same methodology as the one used for the deforestation analysis described in more detail below and in annex 1.
Because of the frequent cloud cover in the Makira area, for each scene and year more than one image had to be acquired. Table 8 shows that a total of 22 Landsat images have been acquired for use in the present deforestation analysis, more than 5 images for each of the 4 observed years. This allowed reducing cloud cover below the 10% threshold of the applied methodology. Selection of the images was based on the following criteria:

- **Acquisition date:** Dates as close as possible to the start of each year of the current monitoring period (2010, 2011, 2012 and 2013) and the start of the subsequent monitoring period (2014).
- **Cloud cover:** As few clouds as possible with a maximum cloud cover of 10% following the applied methodology. For certain dates this was however not possible and images from several dates as close together as possible have been purchase in order to remove clouds (cf. cloud removal process described below).
- **Season:** Images from the dry season were preferred to those from the humid season because they usually have a clearer differentiation of forest from non-forest.

### Table 8: Data used for LU/LC change analysis during the 2010 to 2013 monitoring period

<table>
<thead>
<tr>
<th>Path</th>
<th>Row</th>
<th>Date (Y-M-D)</th>
<th>Type</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>158</td>
<td>070</td>
<td>2011-05-04</td>
<td>LANDSAT 7</td>
<td>LE71580702011124ASN00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2011-05-20</td>
<td>LANDSAT7</td>
<td>LE71580702011140ASN00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2011-09-09</td>
<td>LANDSAT_7</td>
<td>LE715807020111252PFS00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2011-12-14</td>
<td>LANDSAT_7</td>
<td>LE715807020111348PFS00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2011-10-27</td>
<td>LANDSAT_7</td>
<td>LE715807120111300PFS00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2011-12-14</td>
<td>LANDSAT_7</td>
<td>LE715807120111348PFS00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2011-02-21</td>
<td>LANDSAT_5</td>
<td>LT515807120111052JSA00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2012-11-30</td>
<td>LANDSAT_7</td>
<td>LE71580702012335PFS00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2012-11-30</td>
<td>LANDSAT_7</td>
<td>LE71580712012335PFS00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2012-01-31</td>
<td>LANDSAT_7</td>
<td>LE71580712012301PFS00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2012-07-25</td>
<td>LANDSAT_7</td>
<td>LE71580712012207ASN00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2013-12-11</td>
<td>LANDSAT_8</td>
<td>LC81580702013345LGN00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2013-09-06</td>
<td>LANDSAT_8</td>
<td>LC81580702013249LGN00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2013-05-01</td>
<td>LANDSAT_8</td>
<td>LC81580702013121LGN01</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2013-11-09</td>
<td>LANDSAT_8</td>
<td>LC81580712013313LGN00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2013-08-13</td>
<td>LANDSAT_7</td>
<td>LE71580712013225PFS02</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2013-12-11</td>
<td>LANDSAT_8</td>
<td>LC81580712013345LGN00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2014-03-17</td>
<td>LANDSAT_8</td>
<td>LC81580702014076LGN00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2014-07-07</td>
<td>LANDSAT_8</td>
<td>LC81580702014188LGN00</td>
</tr>
<tr>
<td>158</td>
<td>070</td>
<td>2014-02-13</td>
<td>LANDSAT_8</td>
<td>LC81580702014044LGN00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2014-03-17</td>
<td>LANDSAT_8</td>
<td>LC81580712014076LGN00</td>
</tr>
<tr>
<td>158</td>
<td>071</td>
<td>2014-02-13</td>
<td>LANDSAT_8</td>
<td>LC81580712014044LGN00</td>
</tr>
</tbody>
</table>
Based on the acquired remote sensing data, image analysis was conducted in the following steps:

- **Definition of forest**: The forest definition from the Malagasy NDA was again chosen, following which forests are “Stands of trees having at least 30% crown cover, of 5 meters high and at least one hectare in area”. In addition, the analysis excluded all secondary forests of less than 10 years of age.

- **Image Pre-processing**: The detailed procedure of this step is presented in the deforestation analysis report in annex 1.
  - **Projection verification**: For coherence with other studies conducted in Madagascar, the WGS84/UTM 38Sc projection system has been used for all GIS and remote sensing work in Makira. The projection system of each satellite image used for the forest cover change analysis (including images for the final date used for the previous monitoring report) has been verified and corrected if necessary.
  - **Geometric verification**: As the main objective in the forest cover change analysis is to detect change in forest cover between satellite images from different dates, perfect overlap of the used images is crucial. This has been verified visually by superimposing images from different date and comparing them with an easily identifiable polygon such as a river or lake (cf. figure 9 below).

**Figure 9**: Geometric verification of satellite images from 4 different dates against a river polygon

![Geometric verification of satellite images from 4 different dates against a river polygon](image)
- **Removal of clouds, shades and sensor striping:** As mentioned above, it has proved very difficult finding satellite images without clouds for the Makira area. Consequently, several images from the same date have been used and overlapped as described above in order to reduce the cloud cover (cf. table 8 above) and obtain combined scenes with cloud cover below 10%.

  In addition, forest cover data from Hansen et al, available for the 2000 to 2012 time period, has been used to remove clouds, shades and/or stripes that could not be removed with other methods. In this case, the cloud, shade and/or stripe has been replaced with the Hansen vegetation cover from the corresponding year.

- **Data classification:**

  Classification is the process that analysis the pre-treated satellite images and attributes each pixel to one of the eligible land use category, particularly forest and non-forest. A supervised classification process has been implemented that went through the following steps:

  - **Calibration of the classification algorithm using training sites:** In a supervised classification process the quality of the results depends strongly on the selection and the delimitation of training sites. In the current study, these training sites have been delimited on the satellite images mentioned above. At least three different land cover types (e.g. forest, grassland, water, etc.) have been grouped in training site clusters and the clusters have been distributed regularly over the entire intervention zone of the Makira project. In a last step the boundaries of the delimited training sites have been refined by superposing them over high-resolution Spot images, resulting in a spatial database file containing all the identified training polygons.

    Besides the remote sensing data, reflection indexes such as NDVI, NRI and NDWI have been used to assist distinguishing different land cover types, along with morphometric data (altitude, terrain roughness, slope, etc.) derived from a Digital Elevation Model (DEM).

  - **Executing the classification process:** The algorithm “RandomForest” as proposed by Breiman et al. (2001) has been used to process the land cover classification process. “Random Forest” allows a supervised learning method combining an aggregation (bagging) technique with a decision tree algorithm. The algorithm was run under the free statistics software R using and importation package developed by Liaw and Wiener (2002).

    The particular advantage of the RandomForest algorithm for forest cover change analysis is that it is non-parametric, meaning that it does not contain any hypothesis on the distribution of the values of the individuals to be classified. This characteristic is particularly important for large scale forest cover change analysis involving several satellite images and images taken at different dates where spectral response for the same forest class may change from one image to the other. In this case the classes almost always present multi-modal distribution, which makes classic parametric algorithms such as “Maximum Likelihood” inappropriate. In addition, the Random Forest algorithm allows for selecting the most important variables for classification and thus introducing additional variables such as altitude or climatic factors without affecting the strength of the model (see also presentation of the methodology deviations in section 2.2 above).

    In the case of the forest cover change analysis conducted in Makira, the model has been calibrated using 70% of the training data delimited in the training sites. The remaining 30% of the training data was used for model validation (confusion matrix and statistical indicators).
• **Mapping**: Based on results of the previous steps, the following maps were produced for the project area and for the leakage belt:
  - Two forest cover maps have been produced for the start of the current (January 2010) and of the subsequent (January 2013) monitoring period of the Makira project (cf. figure 9).
  - One deforestation map has been produced for the current monitoring period highlighting the difference between the two forest cover maps mentioned above (cf. figure 9).

• **Mapping accuracy**: Accuracy of the produced maps was assessed through analysis of the classification results on 700 randomly selected points in the Reference Area for Localisation (RRL), with 350 points in the Project Area 350 points in the Leakage Belt (cf. figure 9 below). Analysis was based on high-resolution data from LANDSAT and very high-resolution SPOT images, as well as data from the global forest cover analysis conducted by Hansen et al for the 2010 to 2012 time frame. Analysis went through the following steps:
  - Individual classification of each of the 700 selected pixels using the remote sensing data mentioned above with classes FF (forest in 2011 and forest in 2014), FN (forest in 2011 and non-forest in 2014) and NN (non-forest in 2011 and non-forest in 2014).
  - Comparison of the results obtained for the 700 pixels with the corresponding results from the forest cover analysis conducted previously for the entire project area (PA) and Leakage belt (LB).

**Figure 9**: Distribution of randomly selected points in the Project Area (PA) and in the Leakage Belt (LB) for verification of 2010 – 2014 deforestation mapping accuracy
This process led to the two confusion matrices presented in tables 9 and 10 below demonstrating an overall accuracy of 96.57% for the Project Area (PA) and 97.99% for the Leakage Belt (LB), which is clearly above the minimum accuracy threshold of 90% allowed by the applied methodology.

**Table 9:** Confusion matrix assessing deforestation analysis accuracy in the Project Area (PA)

<table>
<thead>
<tr>
<th>Classified Image (CL)</th>
<th>Observation (V)</th>
<th>FF</th>
<th>FN</th>
<th>NN</th>
<th>TOT</th>
<th>User Acc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FF</td>
<td>295</td>
<td>7</td>
<td>2</td>
<td>14</td>
<td>304</td>
<td>97.04%</td>
</tr>
<tr>
<td>FN</td>
<td>1</td>
<td>12</td>
<td>1</td>
<td>14</td>
<td>148</td>
<td>85.71%</td>
</tr>
<tr>
<td>NN</td>
<td>0</td>
<td>1</td>
<td>31</td>
<td>34</td>
<td>350</td>
<td>96.88%</td>
</tr>
<tr>
<td>TOT</td>
<td>296</td>
<td>20</td>
<td>34</td>
<td>350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Accuracy</td>
<td></td>
<td>99.66%</td>
<td>60.00%</td>
<td>91.18%</td>
<td>Overall Acc.</td>
<td>96.57%</td>
</tr>
</tbody>
</table>

**Table 10:** Confusion matrix assessing deforestation analysis accuracy in the Leakage Belt (LB)

<table>
<thead>
<tr>
<th>Classified Image (CL)</th>
<th>Observation (V)</th>
<th>FF</th>
<th>FN</th>
<th>NN</th>
<th>TOT</th>
<th>User Acc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FF</td>
<td>144</td>
<td>2</td>
<td>2</td>
<td>14</td>
<td>148</td>
<td>97.30%</td>
</tr>
<tr>
<td>FN</td>
<td>1</td>
<td>14</td>
<td>0</td>
<td>15</td>
<td></td>
<td>93.33%</td>
</tr>
<tr>
<td>NN</td>
<td>1</td>
<td>1</td>
<td>184</td>
<td>186</td>
<td></td>
<td>98.92%</td>
</tr>
<tr>
<td>TOT</td>
<td>146</td>
<td>17</td>
<td>186</td>
<td>349</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Acc.</td>
<td></td>
<td>98.63%</td>
<td>82.35%</td>
<td>98.92%</td>
<td>Overall Acc.</td>
<td>97.99%</td>
</tr>
</tbody>
</table>

Based on the results of this process, the annual areas for unplanned deforestation in the project case were estimated for each year of the 2010 to 2013 monitoring period and for both of the two considered forest strata. Results are presented in table 11 for the project area and in table 12 for the leakage belt. Figure 10 shows forest cover for each year of the monitoring period and figure 11 deforestation maps for each year (see annex 7 for larger scale maps). Although the methodologies used in 2012 and 2014 were very similar, the results of the two different deforestation analyses for forest cover at the end of the 2005 to 2009 monitoring period led to the following differences:

- **Project area:**
  - The total forest area for 2010 was evaluated at 358,093 ha for the 2014 deforestation analysis, against only 358,045 ha for the 2012 analysis, resulting in a very low difference of only 48 hectares or 0.014%.
  - Comparing data for the two forest strata are much higher with 124,509 ha for low altitude forest and 233,536 ha for mid altitude forests from the 2012 analysis and 119,030 ha for LAF and 239,063 ha for MAF for the 2014 analysis. This difference of more than 5,000 ha is relatively important if compared to the annually deforested area, but if compared to the total area of forest in the Makira Project Area differences are minor with a reduction by 1.53% of the proportion of low altitude forests from 34.77% in the 2012 study to 33.24% in the 2014 assessment and a proportional increase of the proportion of mid-altitude forests by 1.53% from 65.23% in the 2012 Study to 66.76% in the 2014 assessment.

As the two forest strata boundaries are based on altitude it is very probable that these differences are due to the use of different Digital Elevation Models in the two forest cover change assessments. The 2012 study used the 90 m resolution DEM provided by ??? in ????, while the 2014 analyses could use the 30 m DEM developed by ??? in ??? also used...
in the eco-regional forest cover change analysis conducted by the PERR-FH project. As the PERR-FH analysis included numerous partners, was backed by an independent accuracy assessment (cf. section 2.2 and annex 12) and methodologically validated on national level by the Ministry and multiple stakeholders, it was decided to use this data for the present 2010 to 2013 monitoring report.

**Leakage belt:**

With a total of 335,093 ha, the 2012 analysis identified almost 45,000 ha more forest in the leakage belt for early 2010 (cf. relevant tables in section 3.1 and 3.2 above). Of this, around 44,000 ha of difference are located in low altitude forests and less than 1,000 ha in mid altitude forests.

Comparisons between the 2012 and 2014 analysis have shown that this difference is due to erroneous satellite image interpretation in the 2005 to 2009 land cover change assessment, during which large areas of wetlands have been classified as low and sometimes mid altitude forests (cf. annex 13). It appears thus that the new methodology using the Random Forest algorithm allows to more effectively distinguish wet areas from natural humid forest than was the case with the previously used methodology based on the maximum likelihood algorithm. It has consequently been decided to use the results from the 2014 forest as 2010 benchmark for the current 2010 to 2013 monitoring period.

### Table 11: Observed annual areas of unplanned deforestation under the project scenario per forest stratum in the project area for the 2010 – 2013 monitoring period

<table>
<thead>
<tr>
<th>Year</th>
<th>Unplanned deforestation in the Project Area (PA) [ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stratum 1</td>
</tr>
<tr>
<td>2010</td>
<td>154</td>
</tr>
<tr>
<td>2011</td>
<td>235</td>
</tr>
<tr>
<td>2012</td>
<td>446</td>
</tr>
<tr>
<td>2013</td>
<td>141</td>
</tr>
<tr>
<td>Total</td>
<td>975</td>
</tr>
</tbody>
</table>

### Table 12: Observed annual areas of unplanned deforestation under the project scenario in the leakage belt per forest stratum for the 2010 – 2013 monitoring period

<table>
<thead>
<tr>
<th>Year</th>
<th>Unplanned deforestation in the Leakage Belt (LB) [ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stratum 1</td>
</tr>
<tr>
<td>2010</td>
<td>1'114</td>
</tr>
<tr>
<td>2011</td>
<td>1'615</td>
</tr>
<tr>
<td>2012</td>
<td>2'145</td>
</tr>
<tr>
<td>2013</td>
<td>416</td>
</tr>
<tr>
<td>Total</td>
<td>5'291</td>
</tr>
</tbody>
</table>
Figure 10: Digital forest cover maps covering the entire RRD (cf. annex 7 for bigger scale maps)
Figure 11: Digital deforestation maps covering the entire RRD (cf. annex 7 for bigger scale maps)
4.3.1.2 Annual project emissions from deforestation

The net emissions from carbon stock change as a result of deforestation are equal to the area deforested inside the project area multiplied by the emission per unit area. As in Makira there is only one post deforestation stratum, emissions from carbon stock changes could be calculated as follows:

\[
\Delta C_{P,\text{DefPA},i,t} = \sum_{u=1}^{U} (A_{\text{DefPA},i,t} \times \Delta C_{\text{pools,def},i,t})
\]

\[
\Delta C_{P,\text{DefLB},i,t} = \sum_{u=1}^{U} (A_{\text{DefLB},i,t} \times \Delta C_{\text{pools,def},i,t})
\]

Where:

- \( \Delta C_{P,\text{DefPA},i,t} \) = Net emissions from carbon stock change as a result of deforestation in the project case in stratum \( i \) in the project area at time \( t \); t CO\textsubscript{2}-e
- \( \Delta C_{P,\text{DefLB},i,t} \) = Net emissions from carbon stock change as a result of deforestation in the project case in stratum \( i \) in the leakage belt at time \( t \); t CO\textsubscript{2}-e
- \( A_{\text{DefPA},i,t} \) = Area of recorded deforestation in the project area at time \( t \); ha
- \( A_{\text{DefLB},i,t} \) = Area of recorded deforestation in stratum \( i \) in the leakage belt at time \( t \); ha
- \( \Delta C_{\text{pools,def},i,t} \) = Net carbon stock changes in all pools in the project case in stratum \( i \) at time \( t \); t CO\textsubscript{2}-e/ha
- \( t \) = 1, 2, 3, … t years elapsed since the start of the REDD project activity
- \( i \) = 1, 2, 3, … M strata

Emissions per unit area are equal to the difference between the stocks before and after deforestation minus any wood products created from timber extraction in the process of deforestation:

\[
\Delta C_{\text{pools,def},i,t} = C_{\text{BSL},i} - C_{\text{P,post},i} - C_{\text{wp},i}
\]

Where:

- \( \Delta C_{\text{pools,def},i,t} \) = Net carbon stock changes in all pools as a result of deforestation in the project case in stratum \( i \) at time \( t \); t CO\textsubscript{2}-e/ha
- \( C_{\text{BSL},i} \) = Carbon stock in all pools in the baseline case in stratum \( i \); t CO\textsubscript{2}-e/ha
- \( C_{\text{P,post}} \) = Carbon stock in all pools in the post-deforestation stratum; t CO\textsubscript{2}-e/ha
- \( C_{\text{wp},i} \) = Carbon stock in wood products from harvests in stratum \( i \); t CO\textsubscript{2}-e/ha
- \( u \) = 1, 2, 3, … u post-deforestation land uses
- \( t \) = 1, 2, 3, … t years elapsed since the start of the REDD project activity
- \( i \) = 1, 2, 3, … M strata

As mentioned above, carbon stocks in long-term wood products are not considered significant in the case of the Makira project and therefore \( C_{\text{wp},i} \) has been accounted as zero. As only one post-deforestation stratum was identified, this equation could be simplified as follows for the two strata S1 and S2:

\[
\Delta C_{\text{pools,def},S1,t} = C_{\text{BSL},S1} - C_{\text{P,post}} = 544.92 - 262.98 = 306.00 \text{ tCO}_2\text{-e/ha}
\]

\[
\Delta C_{\text{pools,def},S2,t} = C_{\text{BSL},S2} - C_{\text{P,post}} = 813.32 - 262.98 = 571.25 \text{ tCO}_2\text{-e/ha}
\]

This allowed estimating the annual emissions from carbon stock changes due to deforestation in the project area presented in table 13.
4.3.2  Emissions from forest degradation

4.3.2.1  Emissions from forest degradation through wood extraction for timber and fuel

Although forest degradation from wood extraction is considered insignificant in the case of Makira and has therefore not been included in the baseline, emissions from forest degradation have to be monitored using a methodology proposed by the applied VCS methodology. This monitoring results in estimates of emissions from degradation that has occurred in the project area ($\Delta C_{P,Deg}$), through reduction of forest carbon stocks result from either illegal extraction of trees for timber or for fuel and charcoal. As remote methods are not yet capable of measuring biomass stocks and stock changes, a ground-based method proposed by the applied methodology has been used.

Based on this methodology, the forest degradation assessment has been conducted in December 2012 in and around the Makira project area (cf. forest degradation assessment report in annex 6). The assessment was based on semi-structured interviews and focus group discussions organized by the animators of the Makira Project in locations close to relevant access points to the Makira forests (cf. figure 12). These were the entry points of a number of foot-paths leading through the forest (like for instance points K and L on the map in figure 10) but also in the three main controlled occupation zones (ZOC) inside Makira Natural Park (points B, F and H on th map).

The result of this analysis, the forest degradation assessment report, is presented in annex 6. The main conclusion of the assessment is that less than 10% of the interviewed persons believe that forest degradation is occurring in the Project Area. Consequently and in accordance with the applied methodology, forest degradation ($\Delta C_{P,Deg}$) can therefore be assumed to be zero and no additional measurements of forest degradation (limited and extended surveys proposed by the applied methodology) have been conducted.

4.3.2.2  Emissions from forest degradation through natural disturbances

No natural disturbances such as tectonic activity (earthquake, landslide, volcano), extreme weather (hurricane), pest, drought, or fire that result in a degradation of forest carbon stocks have been observed in the project area during the 2010 to 2013 monitoring period. Consequently, related greenhouse gas emissions have been accounted as zero.

Table 13: Estimated emissions from carbon stock changes due to deforestation in the project area and in the leakage belt for the 2010-2013 monitoring period

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Emissions from Carbon Stock Changes [t CO$_2$-e]</th>
<th>Leakage belt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Project area</td>
<td>Leakage belt</td>
</tr>
<tr>
<td>2010</td>
<td>119,922</td>
<td>531,399</td>
</tr>
<tr>
<td>2011</td>
<td>507,708</td>
<td>1,227,711</td>
</tr>
<tr>
<td>2012</td>
<td>661,823</td>
<td>1,279,770</td>
</tr>
<tr>
<td>2013</td>
<td>141,607</td>
<td>215,102</td>
</tr>
<tr>
<td>Total</td>
<td>1,431,060</td>
<td>3,253,983</td>
</tr>
</tbody>
</table>
4.3.3 Project GHG emissions

In accordance with the applied methodology, project emissions were estimated using the following equation:

$$GHG_{P,E,i,t} = E_{FC,i,t} + E_{BiomassBurn,i,t} + N_2O_{Direct-N,i,t}$$
Where:

\[ \text{GHG}_{P,E,i,t} = \text{Greenhouse gas emissions as a result of deforestation activities within the project area in the project case in stratum } i \text{ in year } t; \ t \text{ CO}_2\text{-e} \]

\[ E_{FC,i,t} = \text{Emission from fossil fuel combustion in stratum } i \text{ within the project area in year } t; \ t \text{ CO}_2\text{-e} \]

\[ E_{BiomassBurn,i,t} = \text{Non-\text{CO}_2\text{-e}} \text{ emissions due to biomass burning in stratum } i \text{ in year } t; \ t \text{ CO}_2\text{-e} \]

\[ N_2O_{direct-N,i,t} = \text{Direct N}_2\text{O emission as a result of nitrogen application on the alternative land use in stratum } i \text{ within the project area in year } t; \ t \text{ CO}_2\text{-e} \]

\[ t = 1, 2, 3, \ldots \ t \text{ years elapsed since the start of the REDD project activity} \]

\[ i = 1, 2, 3, \ldots \ M \text{ strata} \]

Project emissions from fossil fuel consumption and from fertilizer application were considered insignificant for the 2010 to 2013 monitoring period and accounted as zero. Consequently, only emissions from biomass burning were monitored as presented in the following sections.

### 4.3.3.1 Emissions from biomass burning

Based on the monitoring plan for the Makira project described in section 3 above, the following three types of biomass burning have been distinguished:

- Conversion of forest land to non-forest land using fire
- Burning in forest land remaining forest land

**Conversion of forest land to non-forest land using fire:**

Annual areas of conversion of forest lands to non-forest land using fire have been delineated by the 2010 to 2013 deforestation analysis (cf. section 4.3.1.1). CO\(_2\) emissions from conversion of forest land to non-forest land using fire are already accounted for as carbon stock changes and therefore only non-CO\(_2\) project emissions are monitored here. In accordance with the E-BB module of the applied methodology and based on the IPCC 2006 Inventory Guidelines, non-CO\(_2\) greenhouse gas emissions from converting forests to non-forests by fire have been estimated as follows:

\[ E_{BiomassBurn,i,t} = \sum_{g=1}^{G} \left( \left( A_{Burn,i,t} \times B_{i,t} \times COMF_i \times G_{g,i} \right) \times 10^{-3} \right) \times GWP_g \]

Where:

\[ E_{BiomassBurn,i,t} = \text{Greenhouse emissions due to biomass burning as part of deforestation activities in stratum } i \text{ in year } t; \ t \text{ CO}_2\text{-e} \text{ of each GHG (CH}_4, \text{ N}_2\text{O)} \]

\[ A_{Burn,i,t} = \text{Area burnt for stratum } i \text{ at time } t; \ \text{ha} \]

\[ B_{i,t} = \text{Average aboveground biomass stock before burning stratum } i \text{, time } t; \ \text{tons d.m./ha} \]

\[ COMF_i = \text{Combustion factor for stratum } i; \text{ dimensionless (see annex 1 for default values as derived from Table 2.6 of IPCC, 2006)} \]

\[ G_{g,i} = \text{Emission factor for stratum } i \text{ for gas } g; \ \text{kg/t dry matter burnt (see section III and annex 2 for default values as derived from Table 2.5 of IPCC, 2006)} \]

\[ GWP_g = \text{Global warming potential for gas } g; \ \text{t CO}_2\text{/t gas } g \text{ (default values from IPCC SAR: CH}_4 = 21; \ \text{N}_2\text{O} = 310)} \]

\[ g = 1, 2, 3 \ldots \ G \text{ greenhouse gases (to include methane and nitrous oxide)} \]

\[ t = 1, 2, 3, \ldots \ t \text{ years elapsed since the start of the REDD project activity} \]

\[ i = 1, 2, 3, \ldots \ M \text{ strata} \]
The average aboveground biomass stock before burning for a particular stratum is:

\[ B_{i,t} = (C_{AB\_tree,i,t} + C_{DW,i,t} + C_{LI,i,t}) \times \frac{12}{44} \times \left( \frac{1}{CF} \right) \]

Where:

- \( B_{i,t} \) = Average aboveground biomass stock before burning stratum \( i \), time \( t \), tons d.m./ha
- \( C_{AB\_tree,i,t} \) = Mean aboveground biomass carbon stock in stratum \( i \) at time \( t \), t CO\(_2\)-e/ha
- \( C_{DW,i,t} \) = Carbon stock in dead wood for stratum \( i \), at time \( t \), t CO\(_2\)-e/ha (cf. annex 1)
- \( C_{LI,i,t} \) = Mean carbon stock in litter for stratum \( i \), at time \( t \), t CO\(_2\)-e/ha (cf. annex 1)
- \( \frac{12}{44} \) = Inverse ratio of molecular weight of CO\(_2\) to carbon, t CO\(_2\)-e/t C
- \( CF \) = Carbon fraction of biomass; t C/t d.m. (default carbon fraction of biomass is 0.47 t C/t d.m.)
- \( t \) = 1, 2, 3, ... t years elapsed since the start of the REDD project activity
- \( i \) = 1, 2, 3, ... M strata

The litter pool has been conservatively excluded from the carbon stock assessment and the above-mentioned equation could be simplified as follows:

\[ B_{i,t} = (C_{AB\_tree,i,t} + C_{DW,i,t}) \times \frac{12}{44} \times \left( \frac{1}{CF} \right) \]

This equation allowed to estimate relevant biomass stocks in the two forest strata considered by the Makira project as follows:

\[ B_{S1,t} = (391.78 + 59.08) \times 0.2727 \times 2.1277 = 261.62 \text{ td.m./ha} \]
\[ B_{S2,t} = (609.59 + 54.25) \times 0.2727 \times 2.1277 = 385.21 \text{ td.m./ha} \]

This value allowed to estimate the non-CO\(_2\) emissions from biomass burning in the project area, assuming that the burned area for each stratum is equal to the annual areas of project deforestation in each stratum in the project area (cf. table 14) and using the following equations:

\[ E_{BB,CH4,S1,t} = \left( A_{burn,t} \times 261.62 \times 0.5 \times 4.7 \times 10^{-3} \right) \times 21 \]
\[ E_{BB,N2O,S1,t} = \left( A_{burn,t} \times 261.62 \times 0.5 \times 0.26 \times 10^{-3} \right) \times 310 \]
\[ E_{BB,CH4,S2,t} = \left( A_{burn,t} \times 385.21 \times 0.5 \times 4.7 \times 10^{-3} \right) \times 21 \]
\[ E_{BB,N2O,S2,t} = \left( A_{burn,t} \times 385.21 \times 0.5 \times 0.26 \times 10^{-3} \right) \times 310 \]
The following default values have been used:

\[ COMF_i = 0.50 \text{ for primary tropical moist forest; dimensionless} \]
\[ G_{g,i} = 4.7 \text{ for } CH_4 \text{ and 0.26 for } N_2O \text{ in tropical forests; kg/t d.m. burnt} \]
\[ GWP_{g} = 21 \text{ t CO}_2/t \text{ gas for } CH_4 \text{ and 310 t CO}_2/t \text{ gas for } N_2O \]

Results for the 2005 to 2009 monitoring period are presented separately for the two considered greenhouse gases (CH\(_4\) and N\(_2O\)) in table 14. The “Makira v8 – 2010-2013 Monitoring” Excel file provides more detail on related calculations.

**Burning in forest land remaining forest land:**

No biomass burning inside forests remaining forest was observed in the Makira protected area during the 2010 to 2013 monitoring period and related project emissions have thus been accounted as zero.

### 4.3.4 Total Project Emissions

Total emissions under the project scenario can be estimated by summing up the different emissions

**Table 16: Estimated emissions under the project scenario in the project area for the 2010 – 2013 monitoring period**

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Emissions [t CO(_2)-e]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deforestation</td>
</tr>
<tr>
<td>2010</td>
<td>102,591</td>
</tr>
<tr>
<td>2011</td>
<td>443,206</td>
</tr>
<tr>
<td>2012</td>
<td>574,757</td>
</tr>
<tr>
<td>2013</td>
<td>122,015</td>
</tr>
<tr>
<td>Total</td>
<td>1,242,568</td>
</tr>
</tbody>
</table>
presented above, mainly emissions from carbon stock changes through deforestation, emissions from forest degradation and emissions from biomass burning. Results are presented in table 16 above, while the "Makira v1 – 2010-2013 Monitoring" Excel file provides more detail.

4.4  **Leakage**

4.4.1  **Leakage to the leakage belt**

Activities that deforestation agents would implement inside the project area in absence of the REDD project activity could be displaced outside the project boundary as a consequence of the implementation of the REDD project activity. Where this displacement of activities increases the rate of deforestation, the related carbon stock changes and non-CO₂ emissions must be estimated and counted as leakage. Leakage is thus defined as the difference between the estimated emissions in the leakage belt under the baseline case and the net emissions from deforestation in the leakage belt under the project scenario and has been estimated using the following equation:

\[
\Delta C_{\text{LK-ASU-LB}} = \Delta C_{\text{P,LB}} - \Delta C_{\text{BSL,unpl.}}
\]

Where:

\[
\begin{align*}
\Delta C_{\text{LK-ASU-LB}} & = \text{Net CO₂ emissions due to unplanned deforestation displaced from the project area to the Leakage Belt; } t \text{ CO₂-e} \\
\Delta C_{\text{BSL,unpl.}} & = \text{Net CO₂ emissions from unplanned deforestation within the leakage belt in the baseline scenario; } t \text{ CO₂-e} \\
\Delta C_{\text{P,LB}} & = \text{Net greenhouse gas emissions from unplanned deforestation within the leakage belt in the project case; } t \text{ CO₂-e}
\end{align*}
\]

Baseline CO₂ emissions from carbon stock changes due to deforestation in the leakage belt (\(\Delta C_{\text{P,LB}}\)) have been presented in section 4.1.2 and table 7 of the present monitoring report. Net emissions from carbon stock changes as a result of deforestation in the leakage belt in the project case (\(\Delta C_{\text{P,LB}}\)) have been estimated in the same way as for the project area and are presented in table 11. In order to prevent positive leakage, \(\Delta C_{\text{LK-ASU-LB}}\) was set to zero if Baseline emissions were higher than project emissions in the leakage belt. Results for the 2010 to 2013 monitoring period are presented in table 17.

---

<table>
<thead>
<tr>
<th>Year</th>
<th>Emissions in the Leakage Belt [t CO₂-e]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
</tr>
<tr>
<td>2010</td>
<td>1,894,886</td>
</tr>
<tr>
<td>2011</td>
<td>1,995,253</td>
</tr>
<tr>
<td>2012</td>
<td>2,095,620</td>
</tr>
<tr>
<td>2013</td>
<td>2,195,987</td>
</tr>
<tr>
<td>Total</td>
<td>8,181,745</td>
</tr>
</tbody>
</table>
The numbers in table 17 show clearly that the expected emissions from carbon stock changes due to deforestation in the leakage belt under the baseline scenario are much higher than emissions from deforestation that really occurred in the project area during the 2010 to 2013 monitoring period. In accordance with the applied methodology and in order to prevent “positive leakage”, leakage emissions have been set to zero.

Figure 13: Migration movements in the humid forest eco-region in Eastern Madagascar
4.4.2 Leakage to outside the leakage belt

Leakage to outside the leakage belt occurs when deforestation agents from outside the leakage belt that would have caused deforestation in the project area under the without project scenario are hindered from immigrating by measures implemented by the project and thus cause emissions from deforestation in areas outside the leakage belt.

The results of regional workshops held under the eco-regional REDD project PERR-FH in 2014 presented in figure 13 above show that the Makira Forests are currently not a major area for immigration. Migrants from the dryer eco-region to the West seem to prefer more accessible areas to the North and to the South of Makira. This seems to be in contradiction with the results of the socio-economic study presented in section the CCB MIR. It has however to be considered that in the Makira area people consider themselves as immigrants for as long as 60 years, much longer than the immigrant definition of less than five years adopted by VCS.

Consequently, the potential for leakage to outside the leakage belt has been accounted as zero, maintaining thus the numbers for leakage presented in table 17.

4.5 Summary of GHG Emission Reductions and Removals

4.5.1 Estimation Of Total Net Greenhouse Gas Emission Reductions

Based on the data presented in the previous sections, the total net greenhouse gas emissions reductions of the Makira REDD project have been calculated as follows:

\[ C_{REDD,t} = \Delta C_{BSL} - \Delta C_P - \Delta C_{LK} \]

Where:

\[ C_{REDD,t} \] = Total net greenhouse emission reductions at time \( t \); t CO\(_2\)-e

\[ \Delta C_{BSL} \] = Net greenhouse gas emissions under the baseline scenario; t CO\(_2\)-e (cf. section 4.2)

\[ \Delta C_P \] = Net greenhouse gas emissions within the project area under the project scenario; t CO\(_2\)-e (cf. section 4.3)

\[ \Delta C_{LK} \] = Net greenhouse gas emissions due to leakage; t CO\(_2\)-e (cf. section 4.4)

Estimated annual emissions and emission reductions in the Makira project for the 2010 to 2013 monitoring period are presented in table 18 (cf. “Makira v4 – 2010-2013 Monitoring” file).

Table 18: Estimated annual emissions and emission reductions in the Makira project for the 2010 - 2013 monitoring period

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated baseline emissions [t CO(_2)-e]</th>
<th>Estimated project emissions [t CO(_2)-e]</th>
<th>Estimated leakage emissions [t CO(_2)-e]</th>
<th>Estimated net GHG emission reductions [t CO(_2)-e]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>599,838</td>
<td>109,555</td>
<td>0</td>
<td>490,282</td>
</tr>
<tr>
<td>2011</td>
<td>631,609</td>
<td>471,162</td>
<td>0</td>
<td>160,447</td>
</tr>
<tr>
<td>2012</td>
<td>663,381</td>
<td>611,714</td>
<td>0</td>
<td>51,668</td>
</tr>
<tr>
<td>2013</td>
<td>695,153</td>
<td>130,088</td>
<td>0</td>
<td>565,065</td>
</tr>
<tr>
<td>Total</td>
<td>2,589,981</td>
<td>1,322,519</td>
<td>0</td>
<td>1,267,462</td>
</tr>
</tbody>
</table>
4.5.2 Estimation of VCS risk buffer

In order to account for non-permanence risks associated with an AFOLU project, the VCS document registration and issuance process requires the set aside of a certain percentage of the total carbon stock benefits in a risk buffer. The most recent version of the VCS AFOLU non-permanence risk tool has been used to determine the non-permanence risk rating for the Makira REDD project as presented in annex 12.

In the case of the Makira project, the overall risk rating obtained through the process described in the PDD was 11. The risk rating for Makira is thus above the minimum non-permanence risk rating of 10 for an AFOLU project (cf. article 2.5.2 of the VCS AFOLU non-permanence risk assessment) and 11 has been used as the final risk rating of the Makira AFOLU REDD project.

To estimate the number of buffer credits that shall be deposited in the AFOLU pooled buffer account, the obtained risk rating has been converted into a percentage that was then multiplied by the net emission reductions generated by the project. As leakage does not factor into the buffer calculations, the following equation was used:

\[
\text{Buffer}_{\text{TOTAL}} = \text{Buffer}_{\text{UNPLANNED}} = (\Delta C_{\text{BSL}} - \Delta C_{P}) \times \text{Buffer}\%\]

Where:

\[
\begin{align*}
\text{Buffer}_{\text{TOTAL}} & = \text{Total permanence risk buffer withholding; t CO}_2\text{-e} \\
\Delta C_{\text{BSL}} & = \text{Net greenhouse gas emissions under the baseline scenario; t CO}_2\text{-e (cf. section 4.2)} \\
\Delta C_{P} & = \text{Net greenhouse gas emissions within the project area under the project Scenario; t CO}_2\text{-e (cf. section 4.4)} \\
\text{Buffer}\% & = \text{Buffer withholding percentage; % (cf. Makira VCS Non-Permanence Risk Report 2010-2013 v5)}
\end{align*}
\]

The non-permanence risk assessment presented in Makira VCS Non-Permanence Risk Report 2010-2013 v6 produced a buffer withholding percentage (Buffer\%) of 10%, which has consequently been applied to the above equation. Annual estimates for the permanence risk buffer withholding for the 2010 to 2013 monitoring period are presented in column 2 of table 19.

4.5.3 Uncertainty Analysis

Estimated carbon emissions and removals arising from AFOLU activities have uncertainties associated with the measures/estimates of: area or other activity data, carbon stocks, biomass growth rates, expansion factors, and other coefficients. The X-UNC module of the applied methodology considers the following sources of uncertainty:

- Uncertainty in the determination of rates of baseline deforestation and degradation
- Uncertainty associated with estimations of stocks in carbon pools and changes in carbon stocks
- Uncertainty in assessment of project emissions

4.5.3.1 Uncertainty in baseline deforestation estimates

Uncertainty related to the regression used to estimate annual areas of baseline deforestation in the RRL have already been estimated in section 3.4.3.1 of the Makira project description and could be taken over directly for the present monitoring report. Uncertainty in baseline deforestation estimates was estimated as follows:

\[
\text{Uncertainty}_{\text{BSL,RATE}} = (1-R^2) \times 100 = (1 - 1) \times 100 = 0\%
\]
4.5.3.2 Uncertainty in baseline carbon stocks estimates

Uncertainty related to estimations of carbon stocks and emission factors in the baseline is estimated in detail in section 3.4.3.2 of the Makira project description. As only emissions from carbon stock changes have been included in the baseline and two forest strata were considered in the Makira project, the following uncertainties for the two considered strata could be taken from the Makira project description:

\[
\text{Uncertainty}_{BSL,SS,1} = \frac{2,326,539.08}{28,514,014.51} = 8.16\%
\]
\[
\text{Uncertainty}_{BSL,SS,2} = \frac{8,181,895.36}{40629795.76} = 20.14\%
\]

Uncertainty in baseline carbon stock estimates was also taken from the Makira project description as follows:

\[
\text{Uncertainty}_{BSL,SS} = \frac{8,506,244.52}{69,143,810.26} = 12.30\%
\]

4.5.3.3 Total uncertainty in baseline emission estimates

In accordance with the X-UNC module of the applied methodology, total uncertainty in baseline emission estimates has been estimated as follows:

\[
\text{Uncertainty}_{BSL} = \sqrt{\text{Uncertainty}_{BSL,Rate}^2 + \text{Uncertainty}_{BSL,SS}^2}
\]

Where:

\[
\text{Uncertainty}_{BSL} = \text{Total uncertainty in baseline scenario}; \%
\]
\[
\text{Uncertainty}_{BSL,Rate} = \text{Percentage uncertainty in the rate of deforestation for areas through time}; \% \text{ (cf. section 4.5.3.1)}
\]
\[
\text{Uncertainty}_{BSL,SS} = \text{Total uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case}; \% \text{ (cf. section 4.5.3.2)}
\]

In the case of Makira uncertainty related to estimation of baseline deforestation rates is 0% and total baseline uncertainty is consequently equal to the uncertainty related to the estimation of carbon stocks:

\[
\text{Uncertainty}_{BSL} = 12.30\%
\]

4.5.3.4 Uncertainty in project emission estimates

Following the X-UNC module of the applied methodology, uncertainties related to the estimation of annual areas of deforestation in the with-project scenario was tracked directly resulting in a map accuracy of 93% (cf. section 4.3.1.1 and annex 1). This accuracy is below the minimum accuracy threshold of 90% required by the BL-UP module of the applied methodology.

For estimating uncertainty in carbon stock estimates for the considered strata, the following equation from the X-UNC module of the applied methodology has been used:

\[
\text{Uncertainty}_{P,SS,i} = \sqrt{\left( \frac{U_{P,SS1} * E_{P,SS1}}{E_{P,SS1} + E_{P,SS2} + \ldots + E_{P,SSn}} \right)^2 + \left( \frac{U_{P,SS2} * E_{P,SS2}}{E_{P,SS1} + E_{P,SS2} + \ldots + E_{P,SSn}} \right)^2 + \ldots + \left( \frac{U_{P,SSn} * E_{P,SSn}}{E_{P,SS1} + E_{P,SS2} + \ldots + E_{P,SSn}} \right)^2}
\]
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Where:

$\text{Uncertainty}_{P,SS,i} = \text{Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in the project case in stratum } i; \%$

$U_{P,SS,i} = \text{Percentage uncertainty (expressed as 95\% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the project case in stratum } i \,(1,2\ldots n \text{ represent different carbon pools and/or GHG sources}); \%$

$E_{P,SS,i} = \text{Carbon stock or GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning etc.) in stratum } i \,(1,2\ldots n \text{ represent different carbon pools and/or GHG sources}) \text{ in the project case}; \, t \text{ CO}_2\text{-e}$

$i = 1, 2, 3 \ldots M \text{ strata}$

In the case of the Makira project, project scenario uncertainties related to the two considered forest strata could be estimated as follows:

$\text{Uncertainty}_{P,SS,1} = 278,587.73 / 3,414,365.40 = 8.16\%$

$\text{Uncertainty}_{P,SS,2} = 736,571.71 / 3,657,680.36 = 20.14\%$

To assess uncertainty across combined strata the X-UNC module of the applied methodology proposes the following equation:

$\text{Uncertainty}_P = \frac{\sqrt{\text{Uncertainty}_{y,1} * E_{P,1} + \text{Uncertainty}_{y,2} * E_{P,2} + \ldots + \text{Uncertainty}_{y,M} * E_{P,M}}}{E_{P,1} + E_{P,2} + \ldots + E_{P,M}}$

Where:

$\text{Uncertainty}_P = \text{Total uncertainty in the with-project scenario; } \%$

$\text{Uncertainty}_{P,i} = \text{Uncertainty in the combined carbon stocks and greenhouse gas sources in the with-project case in stratum } i; \%$

$E_{P,i} = \text{Sum of combined carbon stocks and GHG sources in stratum } i \,(1,2\ldots n \text{ represent different carbon pools and/or GHG sources}) \text{ multiplied by the area of stratum } i \,(A_i) \text{ in the with-project case}; \, t \text{ CO}_2\text{-e}$

$i = 1, 2, 3 \ldots M \text{ strata}$

In the case of the Makira total uncertainty in the with-project scenario is:

$\text{Uncertainty}_P = 787,495.40 / 7,072,045.76 = 11.14\%$

4.5.3.5 Total project uncertainty

Estimation of leakage is conservative in all instances and therefore related uncertainty is assumed to be zero. Total project uncertainty is therefore equal to the combined uncertainty in baseline and with-project estimates and can be estimated using the following equation provided by the X-UNC module of the applied methodology:

$C_{\text{REDD\_ERROR}} = \sqrt{\text{Uncertainty}_{\text{BSL}}^2 + \text{Uncertainty}_P^2}$

Where:

$C_{\text{REDD\_ERROR}} = \text{Total uncertainty for REDD project activity; } \%$

$\text{Uncertainty}_{\text{BSL}} = \text{Total uncertainty in baseline scenario; } \% \text{ (from section 3.4.3.3)}$

$\text{Uncertainty}_P = \text{Total uncertainty in the with-project scenario; } \% \text{ (from section 3.4.3.4)}$
In the case of the Makira project: \[ C_{REDD\_ERROR} = 16.59\% \]

Total uncertainty falls above the 15% threshold advanced by the applied methodology and in accordance with the applied methodology an uncertainty deduction was applied. In order to calculate the uncertainty deduction, the following equation for estimating uncertainty adjusted emission reductions from the X-UNC module was used:

\[ \text{Adjusted } C_{REDD,t} = C_{REDD,t} \times (100\% - C_{REDD\_ERROR} + 15\%) \]

Based on this equation, the total amount of uncertainty deductions can be estimated using the following equation:

\[ \Delta C_{UNC,t} = C_{REDD,t} \times (100\% - (100\% - C_{REDD\_ERROR} + 15\%)) \]

or

\[ \Delta C_{UNC,t} = C_{REDD,t} \times (C_{REDD\_ERROR} - 15\%) = 1.59\% \]

Where:

- \( \Delta C_{UNC,t} \) = Total uncertainty deduction at time \( t \); t CO\(_2\)-e
- \( C_{REDD,t} \) = Total net greenhouse emission reductions at time \( t \); t CO\(_2\)-e (cf. section 4.5.1)
- \( C_{REDD\_ERROR} \) = Total uncertainty for REDD project activity; %

In the case of the Makira project the deduction percentage to be applied is 1.59%. Results for the 2010 to 2013 monitoring period are presented in column 3 of table 19 and detailed calculations in the “Makira v4 – 2010-2013 Monitoring” spreadsheet.

### 4.5.4 Ex-Post Estimation of Verified Carbon Units (VCU)

As demonstrated in the previous sections, total project uncertainty is above the 15% threshold and uncertainty deductions have to be applied. In accordance with the applied methodology, the total amount of Verified Carbon Units generated by the Makira project can be estimated as follows:

\[ VCU_t = C_{REDD,t} - Buffer_{TOTAL,t} - \Delta C_{UNC,t} \]

Where:

- \( VCU_t \) = Total Verified Carbon Units at time \( t \); t CO\(_2\)-e
- \( C_{REDD,t} \) = Total net greenhouse emission reductions at time \( t \); t CO\(_2\)-e (cf. section 4.5.1)
- \( Buffer_{TOTAL,t} \) = Total permanence risk buffer withholding at time \( t \); t CO\(_2\)-e (cf. section 4.5.2)
- \( \Delta C_{UNC,t} \) = Total uncertainty deduction at time \( t \); t CO\(_2\)-e (cf. section 4.5.3.5)

Results for the entire project period of the Makira project are presented in table 19 below. The volume of estimated VCUs for the 2010 monitoring period has been reduced from 433,442 to 279,113 to reflect the deduction of the 154,329 pre-verified emission reductions [t-CO2-e] sold by the Conservation International Foundation on behalf of the Makira project. For more detail on the estimation of total VCUs generated during the 2010 to 2013 monitoring period please refer to the “Makira v4 – 2010-2013 Monitoring” spreadsheet.
Table 19: Ex-post estimation of VCU{s} generated by the Makira project during the 2010 to 2013 monitoring period

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated GHG emission reductions [t CO₂-e]</th>
<th>Estimated risk buffer [t CO₂-e]</th>
<th>Estimated uncertainty deductions [t CO₂-e]</th>
<th>Estimated VCU{s} [t CO₂-e]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>490,282</td>
<td>49,028</td>
<td>7,812</td>
<td>279,113</td>
</tr>
<tr>
<td>2011</td>
<td>160,447</td>
<td>16,045</td>
<td>2,557</td>
<td>141,846</td>
</tr>
<tr>
<td>2012</td>
<td>51,668</td>
<td>5,167</td>
<td>823</td>
<td>45,678</td>
</tr>
<tr>
<td>2013</td>
<td>565,065</td>
<td>56,507</td>
<td>9,004</td>
<td>499,555</td>
</tr>
<tr>
<td>Total</td>
<td>1,267,462</td>
<td>126,746</td>
<td>20,196</td>
<td>966,191</td>
</tr>
</tbody>
</table>
ANNEXES

• Annex 1: Abridged 2010 to 2013 Forest Cover Change Monitoring Report
• Annex 2: Carbon Stock Inventory Report
• Annex 3: MODIS/UMD Fire Monitoring and Alert System
• Annex 4: Environmental permit delivered by ONE
• Annex 5: Makira Natural Park Creation Decree
• Annex 6: Forest degradation PRA report
• Annex 7: Detailed Forest Cover and Deforestation Maps
• Annex 8: Data Management and Storage
• Annex 9: Status of management transfers in the Makira protection Zone
• Annex 10: 2010 – 2013 Non-Permanence Risk Assessment
• Annex 11: Markit Retirement Paper
• Annex 12: Forest cover change assessment methodology comparison
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