República de Moçambique
Ministério da Terra, Ambiente e Desenvolvimento Rural

Mozambique's Forest Reference Emission Level for Reducing Emissions from Deforestation in Natural Forests

Governo de Moçambique

10 January 2018

República de Moçambique

Ministério da Terra, Ambiente e Desenvolvimento Rural

Mozambique's Forest Reference Emission Level for Reducing Emissions from Deforestation in Natural Forests

Version 10 January 2018

1 Executive summary

Main features of the FREL		Remarks
Proposed FREL (in tCO_2/year)	46 213 014	
Type and duration of FREL	Historical average – 11 years (2003-2013)	
Adjustment of national circumstances	None	
National/Subnational	National	National, but reporting estimates at Provincial level and for groups of Districts as Mozambique wishes to pilot REDD+ at a sub-national level.
Activities included	Deforestation	Only deforestation of natural forest. Conversion of plantations is not included.
Pools included	AGB, BGB,	Aboveground and Belowground. Expected to be completed with dead wood and litter in April 2018. SOC will be included in 2019.
Gases included	CO_2	
Forest definition	1 ha, 30% canopy cover, 3 meters tree height	
Relationship with latest GHG inventory	None	Past national communications are not consistent. Mozambique will work through 2018 to ensure consistency.
Description of relevant policies and plans	Yes	This shows that GHG emissions in the historical period are a good proxy of future GHG emissions.
Description of assumptions on future changes in policies	Not applicable	
Description on changes to previous FREL	Not applicable	
Future improvements identified	Include SOC and DOM pools. Include Forest degradation activity.	

2 Table of contents

1 EXECUTIVE SUMMARY 0
2 TABLE OF CONTENTS 1
3 LIST OF TABLES 2
4 LIST OF FIGURES 3
6 ACRONYMS 4
1 INTRODUCTION 5
2 NATIONAL CIRCUMSTANCES 6
2.1 LEGAL FRAMEWORK 6
2.2 CAUSES OF DEFORESTATION AND DEGRADATION 8
2.3 POLICIES AND PLANS 10
3 TRANSPARENT, COMPLETE, CONSISTENT AND ACCURATE INFORMATION 11
3.1 TRANSPARENCY 11
3.2 COMPLETENESS 11
3.3 CONSISTENCY 11
3.4 ACCURACY 11
4 DEFINITIONS 12
4.1 FOREST DEFINITION AND OPERATIONALIZATION 12
4.2 LAND USE LAND COVER CLASSIFICATION SYSTEM 12
5 SCALE AND SCOPE 14
5.1 SCALE 14
5.2 REDD+ ACTIVITIES 14
5.3 CARBON POOLS 15
5.4 GASES 16
6 REFERENCE PERIOD AND VALIDITY PERIOD 16
6.1 REFERENCE PERIOD 16
6.2 FREL VALIDITY PERIOD 16
7 METHODOLOGICAL CHOICES 17
7.1 APPROACH TO SET FREL/FRL 17
7.2 IPCC METHODS USED 17
8 ACTIVITY DATA 18
8.1 SOURCE 18
8.2 SAMPLING DESIGN 19
8.3 RESPONSE DESIGN 19
8.3.1 Spatial sampling unit 19
8.3.2 Source of reference data 19
8.3.3 Reference labelling protocol 20
8.4 ANALYSIS AND RESULTS 21
8.4.1 Analysis design 21
8.4.2 Results for activity data 22
9 EMISSION FACTORS 25
9.1 SOURCE 25
9.2 SAMPLING DESIGN 25
9.3 DATA COLLECTION 27
9.4 ESTIMATION 28
9.5 ANALYSIS AND RESULTS 29

9.5.1 Analysis 29
9.5.2 Results 31
10 FOREST REFERENCE LEVEL 33
10.1 NATIONAL CIRCUMSTANCES 33
10.2 CALCULATION 33
10.3 PROPOSED FREL 33
10.4 ANALYSIS OF UNCERTAINTY 34
11 IMPROVEMENT PLAN 35
11.1 CAPACITY BUILDING NEEDS 35
11.2 AREAS OF IMPROVEMENT 36
12 REFERENCES 37

3 List of Tables

Table 1. Land use and Land Cover classification system used in the production of the maps, activity data and national forest inventory. 13
Table 2. Overview of the Land Use, Land Use Change and Forestry (LULUCF) between 2003 and 2013 per forest stratum and forest type 23
Table 3. Land Use, Land Use Change and Forestry between 2003 and 2013 24
Table 4. Distribution of the Number of samples of NFI per Province 26
Table 5. Models used to estimate biomass of each stratum and species. 28
Table 6. Area, proportion and sample size per stratum 29
Table 7. Above-ground biomass (AGB), above-ground carbon (AGC) and carbon dioxide equivalent or emission factor for AGB (CO2eq (A)) 31
Table 8. Below ground biomass (BGB), below ground carbon (BGB) and carbon dioxide equivalent or emission factor for BGB (CO2eq (B)) 31
Table 9. Total tree biomass (TB = AGB + BGB), total tree carbon (TC = AGC + BGC) and carbon dioxide equivalent or emission factor for TB (CO2eq (T)) 31
Table 10. Above- and below-ground biomass in mangroves 32
Table 11. Standard error and sampling error of estimates 32
Table 12. Calculation of FREL. 33
Table 13. Total and annual average of emissions of C02 per stratum per year (FREL) 33
Table 14. Uncertainty per stratum 35

4 List of Figures

Figure 1. Proportion of deforestation for each driver (data from Ceagre and Winrock International, 2016) ... 9

Figure 2. Image of the spatial sampling unit ... 19

Figure 3. LULC changes detection using Collect Earth Tool. (www.openforis.org). Forms designed with Collect Tool. ... 20

Figure 4. A temporal analysis of LULC changes of one point from national 4km x 4 km grid sampling. ... 20

Figure 5. Decision tree for the allocation of the IPCC Land Use category based on the cover of the objects present in the sampling unit ... 21

Figure 6. Deforestation in Mozambique between 2003 and 2013 ... 23

Figure 7. Sampling locations of the NFI. The maps lacks the samples of Cabo Delgado and Gaza. ... 26

Figure 8. National Forest Inventory plot layout. ... 28

Figure 9. Graphical representation of emission from deforestation per year ... 34

6 Acronyms

AGB	Aboveground Biomass
BGB	Belowground Biomass
CEAGRE	Centre for Agricultural Studies and Natural Resource Management (*Centro de Estudos de Agricultura e Gestão de Recursos Naturais*)
CENACARTA	National Center for Cartography and Remote Sensing
D&D	Deforestation and Forest Degradation
DINAB	National Directorate of Environment
DINAF	National Directorate of Forests
DINAT	National Directorate of Land
DOM	Dead Organic Matter
FAO	Food and Agriculture Organization of the United Nations
FNDS	National Fund for Sustainable Development
FRA	Global Forest Resource Assessment
FREL	Forest Reference Emissions Level
GHG	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
LULC	Land Use and Land Cover
MASA	Ministry of Agriculture and Food Security
MIREME	Ministry of Natural Resources and Energy.
MITADER	Ministry of Land, Environment and Rural Development
NFI	National Forest Inventory
NGO	Non-governmental Organizations
REDD+	Reducing emissions from deforestation and forest degradation and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks
SOC	Soil Organic Carbon
UEM	Eduardo Mondlane University
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

Mozambique is a country located in the southeast Africa bordered by the Indian Ocean with boundaries in the North with Tanzania, Zambia Northwest, Malawi, Zimbabwe and Swaziland in the west and south with South Africa. The total extension is 800 000 Km2 in which 43% is covered by natural Forests and the total Population estimated in 28 million inhabitants.

Forests play an important role in the economy of the country, especially in the rural areas and provide direct benefits to a large majority of the population as source of energy through the extraction of firewood and charcoal, construction materials, logging for timber, non-timber forest products (medicinal plants, fruits, etc.), source of nutrients for small scale agriculture.

The third National Forest inventory reports findings estimated that forests in Mozambique have suffered high rates of deforestation, estimated at 0.58% in 2007, corresponding to 220 000 ha/year. Acknowledging this situation, and understanding its impact to the economy and to the livelihood of rural population, the Government of Mozambique became part of the 47 Countries that benefited from funds from the Forest Carbon Partnership Facility (FCPF) to develop the National REDD+ strategy with the aim of reducing emissions from deforestation and forest degradation and enhancement of carbon stocks (REDD+). The process began in 2008 with the elaboration of the REDD+ readiness plan (R-PP), which was approved by the Committee of Participants of the FCPF in March 2012. In 2016, the country received additional funds from the FCPF to establish a National Forest Monitoring System (NFMS) and the Forest Reference Emission Level / Forest Reference Level (FREL) of greenhouse gas emissions (GHG) for REDD+.

With the aim of consolidating the process of REDD+, Mozambique embraces the opportunity to submit a proposal of FREL to the United Nations Framework Convention on Climate Change (UNFCCC), responding to decision 1/CP.16, referring to the requests of developing countries with intention to perform activities related to REDD+.

The objective of the country, in submitting this proposal, is on the perspective of building capacity for the implementation at all levels, the National REDD+ Strategy recently approved by the Government in December 2016 aiming to promote sustainable development, resilience to climate change, integrated rural development focused in forest, agriculture and energy.

The reduction of emissions caused by deforestation and forest degradation (REDD+), is an initiative of the Signatory States to the United Nations Framework Convention on Climate Change (UNFCCC), has its primary objective the promotion of actions which result in the reduction of deforestation and forest degradation, as well as an increase forest cover through forest plantations, restoration of degraded forests, conservation of forest ecosystems and improvement of sustainable forest management practices.

This proposal was constructed using the best available information in the country, following the IPCC guidance and guidelines, adopting the ''stepwise'' approach accepted by Decision 12/CP.17, para 10.

As part of the actions related to REDD+, the Government of Mozambique is implementing the Forest

Investment Program of Mozambique (MozFIP) and the Zambézia Integrated Landscape Management Program (ZILMP). MozFip was created in the framework of the Climate Investment Funds (CIF), to support the efforts of REDD+ in Developing Countries. The ZILMP was created with the aim of promoting sustainable development through the conservation and management of forests with insertion on the efforts of REDD+ in nine (9) districts of the Zambézia Province, namely, Gilé, Ile, Pebane, Alto Molocué, Maganja da Costa, Mocubela, Mulevala Mocuba e Gurué. The Government of Mozambique is planning to use the ZILMP as a pilot to test REDD+ and performance based payments. It is expected that it will enter into an Emission Reduction Payment Agreement (ERPA) with the FCPF Carbon Fund in 2018. Moreover, the Government of Mozambique is also planning a second sub-national pilot REDD+ program around and within the Quirimbas National Park, in seven (7) districts of the Cabo Delgado Province, namely Macomia, Quissanga, Meluco, Montepuez, Metuge, Ancuabe and Ibo, covering an area of 30 405 km^2, with an annual deforestation estimated in 5 522 hectares/year equivalent to 0,31%. There is a structure of implementation in place created by MITADER and few initiatives working in improved cook stoves, kilns, to reduce the pressure of forests from the use of low efficient technologies to produce and use charcoal, other are working in agriculture introducing and disseminate sustainable agriculture good practices, to reduce the pressure to the forests, improve the productivity and the value chain. The main challenge is the involvement of the private sector in sustainable forest management and expansion of these initiatives to all districts to a larger number of beneficiaries to reduce the current pressure the Program Area is suffering, especially the Quirimbas National Park. The Government is planning to submit this sub-national REDD+ program to the request for proposals for Result Based Payments of the GCF.

2 National circumstances

This chapter on national circumstances provides information on the legal framework and institutional arrangements, which comprises the description of the laws, regulations, Decrees, Diplomas existent in the country which supports the efforts for reducing emissions from deforestation and forest degradation and identifies the gaps and the actions in place towards a solid legal framework. This includes a description of institutional arrangements for MRV system and the potential gaps for its effective implementation. Furthermore, a description on drivers of deforestation is provided which includes information of the current deforestation, identifies the main drivers of deforestation and forest degradation and its contribution to total deforestation. To end with, this chapter provides information on plans and policies in terms of what is intended to do in view of the current institutional and legal framework and the drivers of deforestation. Plans are more operational and they will be applied in the coming five to 11 years from now and include the roadmap for the implementation and operationalization of the countries Measurement, Reporting and Verification system[1] (MRV).

2.1 Legal framework

In 1992 Mozambique adhered to the Rio convention to contribute to the sustainable use of natural

[1] http://www.redd.org.mz/uploads/SaibaMais /ConsultasPublicas/MRV%20Road.pdf

resources. As a result, an Environment law (Decree Nr. 20/97) was drawn up, which defines the legal basis for the improved use and management of the environment and its components, to achieve sustainable development. This law prohibits the pollution of air water and soil and practices that accelerate erosion, desertification and deforestation. Deforestation is the main topic that deserves attention in the forest sector as it is the main threat to the sustainability of forest natural resources. To enforce the legal framework, the Forest and Wildlife Law (Decree N°. 10/99) was approved in 1999 to ensure the protection, conservation, development and rational use of forest and wildlife resources for economic, social and ecological benefit of current and future generations of Mozambicans. The implementation of the forest Law was then reinforced by its regulation (Decree 12/2002) which is focused on the management of forest activities, community engagement and law enforcement. After the Bali Conference (COP 13), which recognized the contribution of REDD+ to climate change, Mozambique started to find ways to improve the management of its forests. In 2008, Mozambique prepared the first Emissions Reduction Project Idea Note (ER-PIN) that created conditions for preparing the legal and institutional grounds for REDD+. During this period, the country produced the REDD+ Decree (Decree 12/2013) which establishes the institutional arrangements in terms of MRV, establishes that the Government of Mozambique has the right to validate, verify and issue Emission Reductions titles and provides procedures for licensing REDD+ projects that wish to generate titles of Emission Reductions. As part of the REDD+ Readiness phase, the country produced the National REDD+ strategy in 2016. This strategy impacted significantly the forest related laws, policies and National Programs. Currently the forest sector is making reforms on the law, regulation, policy and strategy and the national forest program.

In 2017, Mozambique ratified the Paris Agreement and agreed to the global target of keeping global average temperatures well below 2°C. To achieve this, the country is in a process of designing the National MRV system which comprises four Components: AFOLU, Transport, Energy and Solid Residues. The MRV for REDD+ is part of the AFOLU, and is intended to conduct the following activities:

- Monitor GHG from deforestation and forest degradation which includes the monitoring of changes in land use and land cover, forest inventory, monitoring with a network of permanent sampling plots and estimation of GHG emissions and removals.
- Development of the National Platform for Sustainable Management of Natural Resources, which comprises the REDD+ programs and projects, Safeguard Information System (SIS), Grievance Redress Mechanism, benefit sharing and transactions.
- GHG reporting at national and international level.
- Periodical evaluations of REDD+ programs and projects.

To achieve the intended activities, ongoing efforts are taken ahead by different institutions within the Ministry of Land, Environment and Rural Development (MITADER), Ministry of Agriculture and Food Security (MASA), Eduardo Mondlane University (UEM) and Ministry of Natural Resources and Energy. Within MITADER, the institutions involved are the National Directorate of Forests (DINAF), National Directorate of Land (DINAT), National Directorate of Environment (DINAB), National Center for Cartography and Remote Sensing (CENACARTA) and The National Fund for Sustainable Development (FNDS).

As part of the recent experience working on the production of the emission factors during the fourth National Forest inventory the Roles of the institutions involved were:

- DINAF (MITADER) : Leader of the National Forest Inventory, Quality control and Quality assurance
- FNDS (MITADER) : Coordinate the operations and logistics of the National Forest inventory
- IIAM (MASA)- Supply technical staff for identification of species and field work
- FAEF (UEM)- Soil analysis, supporting on the production of the Report of the National Forest Inventory, supplied allometric equations to estimate the carbon pools
- FCB (UEM) - Supplied technical staff for identification of species
- To produce the activity data, the following institutions were involved:
- DINAF (MITADER) - Provided conditions to train MRV unit team to learn the use of Collect earth used to produce the activity data; provided the National 4x4 km grid and did the Quality assurance of the activity data;
- FNDS (MITADER) - Produced the activity data
- CENACARTA-(MITADER) - Did the assessment of process of production of data

With regards to the production of activity data and emission factors, the arrangements have been agreed to, but not formalized. One of the challenges is the formalization of institutional coordination, which requires policies on data sharing to be well defined and the institutions strategic plans harmonized.

2.2 Causes of deforestation and degradation

A study conducted by CEAGRE and Winrock International (2016) analyzed seven drivers of Deforestation and Degradation (D&D): commercial agriculture, shifting agriculture, extraction of timber products, production of firewood and charcoal, urban expansion, mining and livestock. This analysis considered that the seven drivers are interrelated in a multitude of ways and together are responsible for most of the D&D that occurs in Mozambique.

The study found that shifting agriculture is the major cause of deforestation in Mozambique, being responsible for 65% between 2000 and 2012. The other major causes identified were urban expansion (12%), extraction of timber products (8%) and production of firewood and charcoal (7%).

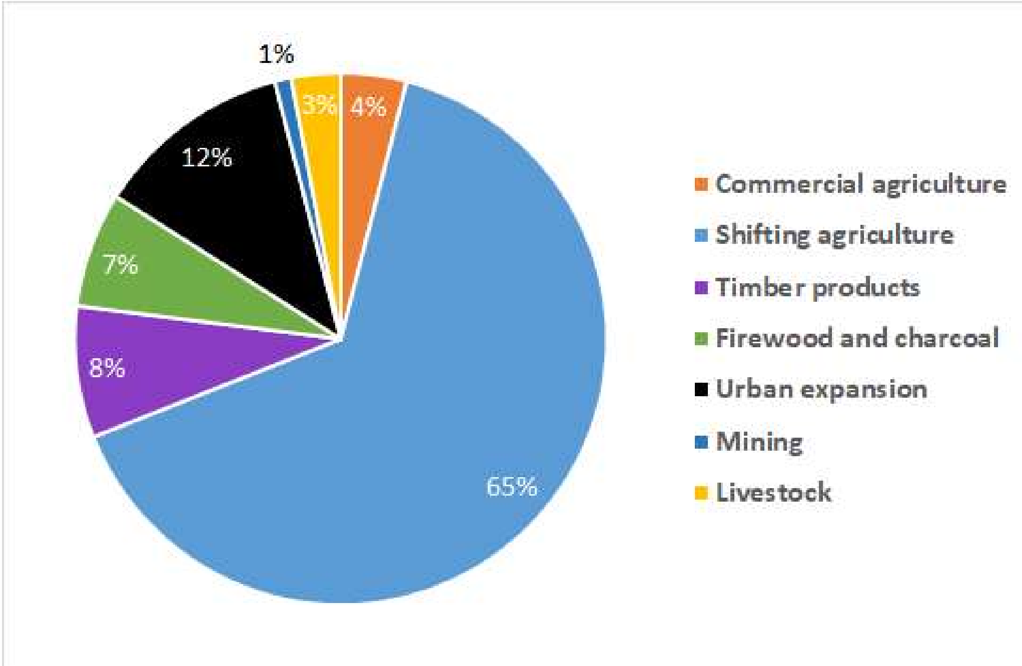

Figure 1. Proportion of deforestation for each driver (data from Ceagre and Winrock International, 2016)

On the other hand, the activity data analysis presented in this report showed that 66.8% of all deforestation events were due to conversion to agriculture, 31.5% to conversions to grassland, with the remaining conversions being responsible for less than 2%. Although the two analyses have very different methodologies, they both agree that agriculture is the main driver of deforestation (66.8% vs. 65%). Additionally, if we interpret a conversion to grassland as resulting from timber product extraction, production of firewood, charcoal and livestock, then the two studies also show agreement, since these three drivers are responsible for 18% of deforestation in the study by CEAGRE and Winrock International (2016). The largest difference between these two analyses is in the role of urban expansion as a driver of deforestation. This could be explained because in the activity data only direct conversions were measured, whereas urban expansion can have multiple indirect effects of deforestation rates.

In the study by CEAGRE and Winrock International (2016), the main drivers vary per Province, according to each Province's economic, social and natural characteristics. In the south of Mozambique (Maputo, Gaza and Inhambane Provinces), urban expansion has a much greater impact on deforestation (23%) than in other regions of the country (7% in the north and 11% in the centre). In the Northern Provinces (Cabo Delgado, Nampula and Niassa), shifting agriculture has a greater impact on emissions (72%) than the centre (60%) or south (59%) of the country. The type of forest can also have an impact on deforestation rate. For example, mopane forests are more affected by charcoal production, timber exploration and grazing, whereas miombo forests are more heavily impacted by agriculture.

This study predicted that the deforestation rate of Mozambique is expected to increase in the next 10 years, due to population growth and urban growth. On the other hand, improvements in the forest management process may lead to a significant reduction in illegal timber exploration, which may result in reduced rates of D&D. The impact of the drivers of forest degradation was assumed to have been captured in the estimation of deforestation, since the analysis assumes that the drivers of deforestation and forest degradation are multiple and complex and act in unison.

A first order estimation of emissions resulting from the three most important causes of forest degradation (timber exploration, production of firewood and charcoal, and wildfires), predicted that forest degradation is responsible for almost 30% of total emissions.

2.3 Policies and plans

In order to implement the REDD+ strategy, the Government of Mozambique is reformulating the policies in the forest sector, and testing the implementation of programs and projects on the ground. Two programs are being currently being implemented at sub-national level: the Zambézia Integrated Landscape Management Program (ZILMP) and the Integrated Landscape Management Program in Cabo Delgado Province (PROGIP-CD). The ZILMP was created with the aim of promoting sustainable development through the conservation and management of forests with insertion on the efforts of REDD+ in nine (9) districts of the Zambézia Province, namely, Gilé, Ile, Pebane, Alto Molocué, Maganja da Costa, Mocubela, Mulevala Mocuba e Gurué. The Government of Mozambique is planning to use the ZILMP as a pilot to test REDD+ and performance based payments. It is expected that it will enter into an Emission Reduction Payment Agreement (ERPA) with the FCPF Carbon Fund in 2018. The second sub-national pilot REDD+ (PROGIP-CD) program covers nine (9) districts of the Cabo Delgado Province, namely Macomia, Pemba-Metuge, Montepuez, Ibo, Ancuabe, Quissanga and Meluco. This area has the Quirimbas National Park which cover 9 130 Km^2, that is under pressure due to human activities. Agriculture, demand for fuelwood and charcoal, urban expansion, illegal logging and mining are the main drivers of deforestation and forest degradation. Is to reduce the pressure especially in the Quirimbas National Park, by promoting sustainable practices in agriculture, timber extraction and in charcoal production. The Government is planning to submit this sub-national REDD+ program to the request for proposals for Result Based Payments to GCF, and find possible collaborations with different parties for its implementation.

In terms of the MRV system for REDD+, there are also plans for future work on the production of emission factors and activity data. In 2018 and 2019, the establishment of the National network of Permanent Sample plots in the country will be conducted. This activity will be led by IIAM (MASA), with the direct involvement of FNDS (MITADER), DINAF (MITADER), FAEF (UEM) and FCB (UEM).

The National Platform for Management of Natural Resources that initially was being developed by DINAF is in a process of redesign due to the new requirements of the MRV system. In general, it is expected that data sharing policies, quality assurance and quality control, and institutional coordination are reflected in the reforms that are happening in the forest sector.

3 Transparent, complete, consistent and accurate information

3.1 Transparency

Both the activity data and the NFI results will be published in individual reports and in this report. Once the National Platform for Management of Natural Resources is online, it will be possible to access the results. The reviewers of the technical assessment under the UNFCCC will have access to all relevant files.

To ensure transparency on the process, the guidelines are available on the web[23]. Transparency is also guaranteed with the consultation with different stakeholders on the process of defining the period, the selection of the allometric equations, dissemination of the documents and information to the public for comments, consultation and use.

3.2 Completeness

The methodology used to calculate the activity data, emission factors and the FREL itself is described in detail in this document (Section 8 and 9). The data used in the calculations is available and thus the FREL can be reconstructed independently.

3.3 Consistency

The future GHG inventories will adhere to the definitions used in this FREL, thus ensuring consistency between the two.

3.4 Accuracy

Regarding emission factors, data was collected by a well trained and certified team of forestry engineers that conducted the field work and supervised by the QA/QC team and an independent auditor. Data transfer was done in digital form and it was subject to QA by a team not involved in the data collection. Processing was done in an automated way by a researches with QA conducted by a team not involved in the processing.

Regarding activity data, data was collected by a well-trained team of 5 forestry engineers who worked for 4.4 months on the data collection. QC/QA procedures were in place in order to ensure the consistent collection and transfer of data.

The consistency of the information of the emission factors and activity data are guaranteed by the guidelines[2], which provides procedures to collect the data. It also enforced by the supervision and QA/QC) and external audit.

2 http://www.redd.org.mz/uploads/SaibaMais/ConsultasPublicas/AD%20Accuracy%20Assessment.pdf

3 http://www.redd.org.mz/uploads/SaibaMais/ConsultasPublicas/Mozambique%20National%20Forest%20Inventory%20Guidelines.pdf

4 Definitions

4.1 Forest definition and operationalization

In Mozambique forests are defined as lands with trees with the potential to reach a height of 3 m at maturity, a canopy cover equal or greater than 30%, and that occupy at least 1 ha. This includes temporarily cleared forest areas and areas where the continuity of land use would exceed the thresholds of the definition of forest, or trees capable of reaching these limits in situ (Falcao and Noa 2016[4]).

Mozambique's previous forest definition was land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. This definition was changed after a long consultation process that involved the relevant public sector institutions, NGO, private operators and research institutions. The area requirement was increased to facilitate the mapping using remote sensing techniques, with medium resolution satellites. With regards to the canopy cover, it was considered that the value of 10% leads to the inclusion of forested areas with low carbon stocks, lowers the rate of deforestation, increases the monitoring costs and makes projects less attractive to investors. The minimum height was reduced from 5 to 3 meters to include forests with shorter trees, but with significant carbon stocks, such as mangrove and mopane forests.

Thus, the forest definition used in this FREL will differ from the definition presented in FRA 2015, which used the old forest definition. It is expected that the next FRA the forest definition and the estimates will be updated with the newly collected activity data. The country's proposal to the CDM of the UNFCCC in 2012/13 was also different, having changed the minimum tree height from 3 to 5 meters, following the definition proposed at the time by the National Directorate of Land and Forests[5].

4.2 Land Use Land Cover classification system

The 2006 IPCC Guidelines considers the following land-use categories for greenhouse gas inventory reporting: forest land, cropland, grassland, wetland, settlements and other land. Mozambique uses a tiered land use land cover (LULC) classification system, nested within the IPCC system.

The IPCC system was used as a basis in the National Forest Inventory (NFI), activity data and in the LULC cartography that is being generated. However, the national system places emphasis on the forest class, differentiating between different major forests types present in the country. It includes two levels, considering level 1 as the IPCC system, level 2 which distinguishes between closed and open canopies, as well as evergreen or deciduous forests. It also includes a forest plantation class. At level 3 the forest types are further differentiated, with the evergreen forests including mountainous forest, gallery forest, mangrove, coastal forest and Mecrusse forest (dominated by Androstachys johnsonii). The deciduous forest types are miombo (dominated by Brachystegia *sp*. and Julbernardia sp.) and mopane (dominated by Colophospermum mopane).

[4]http://www.redd.org.mz/uploads/SaibaMais/ConsultasPublicas/Relatorio%20definicao%20de%20floresta%20V5_19.10.2016.pdf

[5] http://cdm.unfccc.int/DNA/index.html

A more detailed description of the LULC system is presented in Annex 1.

Table 1. Land use and Land Cover classification system used in the production of the maps, activity data and national forest inventory.

Level 1 IPCC	Level 2 National Classification	Level 3 National Classification
Crops	Tree crops	Tree crops
	Field crops	Shrub Plantation (Tea)
		Rainfed field crops
		Irrigated field crops
		Rice crop
	Shifting cultivation with open to closed forested areas	Shifting cultivation with open to closed forested areas
Forests	Forest Plantation	Forest Plantation
	Forest with shifting cultivation	Forest with shifting cultivation
	Broadleaved (Semi-) evergreen closed forest	Coastal dense woody vegetation
		Mangrove dense
		Mecrusse dense
		Gallery forest
		Closed broadleaved (Semi-) evergreen mountainous forest
	Broadleaved (Semi-) deciduous closed forest	Miombo dense
		Mopane dense
	Broadleaved (Semi-) evergreen open forest	Coastal open woody vegetation
		Mangrove open
		Mecrusse open
		Open broadleaved (Semi-) evergreen mountainous forest
	Broadleaved (Semi-) deciduous open forest	Mopane open
		Miombo open
Grassland	Grasslands	Grasslands

Level 1 IPCC	Level 2 National Classification	Level 3 National Classification
	Thicket	Broadleaved (Semi-) evergreen thicket
		Broadleaved (Semi-) deciduous thicket
	Shrubland	Broadleaved (Semi-) evergreen shrubland
		Broadleaved (Semi-) deciduous shrubland
Wetlands	Aquatic or regularly flooded shrublands	Aquatic or regularly flooded shrublands
	Aquatic or regularly flooded herbaceous vegetation	Aquatic or regularly flooded herbaceous vegetation
	Artificial water bodies	Artificial water bodies
	Natural water bodies	Natural water bodies
	Salt lake	Salt lake
Settlements	Settlements	Settlements
Other land	Bare soils	Bare soils
	Bare rocks	Bare rocks
	Dunes	Dunes

5 Scale and scope

5.1 Scale

This scale of the presented FREL are all forests within Mozambique except for any island territory of Mozambique.

However, Mozambique wishes to report estimates at the Provincial level and at the level of the sub-national REDD programs as Mozambique wishes to implement REDD+ following a step-wise approach that eventually lead to a national REDD+ program and seek REDD+ result based payments for areas within Mozambique. This is important as the country does not have the capacity to implement investment activities and implement the REDD+ framework (e.g. Safeguard Information System) at full national scale at this time.

5.2 REDD+ activities

The five REDD+ activities are:

- Reducing emissions from Deforestation
- Reducing emissions from forest degradation
- Conservation of forest carbon stocks
- Sustainable forest management
- Enhancement of carbon stocks

Mozambique defined deforestation as the anthropogenic conversion of forest land to non-forest land. Afforestation is the conversion from non-forest to forest, includes new forest plantations as well as regrowth of natural forests on old cropland or grassland. Forest degradation is defined as the long-term reduction of forest canopy cover or carbon stock, which results in a reduction of the benefits obtained from the forest, including timber, biodiversity and other goods and services. This reduction can result from timber exploration, fires, cyclones and other causes, as long as the canopy cover remains above 30%. Enhancement of forest carbon stocks is an activity that refers to the increase in carbon stocks on forest land that remains forest land.

For the purposes of this FREL, the **only activity included is reducing emissions from deforestation**. The main activities to reduce emissions from deforestation are sustainable agriculture, Agroforestry, improved kilns for charcoal, improved cook stoves, land use planning.

Although estimates of activity data for afforestation/reforestation are available, and activities that enhance carbon stocks are being developed in the country (e.g. MozFIP and MozBIO) **this activity is not included** in the meantime due to the lack of removal factors that would allow to estimate GHG removals.

Although degradation is thought to be an important component of GHG emissions in Mozambique's forests (CEAGRE and Winrock International 2016), the country is still developing the methodology to estimate emissions from forest degradation so this activity **is not included**. This development will take place throughout 2018 and is expected to be finalized by 2019. Nevertheless, there is no indication that measures intended to reduce deforestation would result in leakage towards degradation. As a result, excluding forest degradation in the current submission is conservative, i.e. underestimates GHG emissions which in turn underestimates emission reductions.

Regarding conservation of forest carbon stocks, the main activities are establishment of conservation areas in community areas, maintenance and protection of Reserves and Parks, but it is assumed that the source of GHG emissions are included in deforestation and forest degradation, so it is not selected as activity. Moreover, Sustainable forest management includes as main activities monitoring the management plans, law enforcement QA/QC for management plans of concessions, but in terms of GHG emissions it will be assumed as part of deforestation and forest degradation.

The selection of the activities must be based on information on drivers of deforestation, as well as based on regional and national priorities.

5.3 Carbon pools

This report includes information on aboveground biomass (AGB) and belowground biomass (BGB). The information on AGB is sourced from the NFI for all forests except for mangrove, which was not covered by the NFI. For this forest type, IPCC default values for Mangrove (Tier 1) have been used instead. Although Tier 2 values exist for Mozambique based on peer reviewed studies, the use of one or other value would not have any impact as deforestation in Mangrove is so little. Information on BGB was obtained from allometric equations, where available, or root to shoot ratios (R: S). for more details see Table 7 in section 9.

The information on dead organic matter (DOM), including litter and dead wood, obtained from the NFI is still being processed and so will not be included in this report. It is expected to be included in the modified submission on proposed reference level in April 2018.

The analysis of soil samples collected during the NFI is still ongoing and is expected to be concluded during 2018. It is not expected to be finished in time for soil organic carbon (SOC) to be added to the modified submission so this will be subject to future revisions, perhaps in January 2019.

5.4 Gases

Carbon Dioxide (CO_2) is the only GHG included in Mozambique's FREL. Methane (CH_4) is emitted from clearance and conversion of peat land and wetlands or from forest fires. Considering that no peatlands and very few organic soils exist in Mozambique (concentrated in Mangroves) and the little deforestation in wetlands, CH_4 emissions from anaerobic decomposition is considered null.

CH_4 Emissions from forest fires, including N2O emissions, may be significant. A significant portion of Mozambique burns annually, since it is a common practice during the clearing of agricultural fields, hunting wild game and gathering of honey (Sitoe *et al.* 2012). However, there currently is no validated information on burned area for the country nor the emissions resulting from those fires. The inclusion of emissions from fires is something that will be studied and, if found to be significant, it will be included in subsequent FRELs.

6 Reference period and validity period

6.1 Reference period

The UNFCCC does not give any directives with regards to the reference period for the FREL. However, both The Forest Carbon Partnership Facility (FCPF) and Green Climate Fund (GCF) have specific guidelines. FCPF sets a minimum of 10 years and a maximum of 15 years, while GCF gives a better score for a reference period between 10 and 15 years, but allows the reference period to be set from 5 to 20 years.

The chosen period for the definition of the FREL is from **2003 to 2013**. This was the period chosen by the National Directorate of Forests, when they initiated a project to produce LULC change maps for Gaza and Cabo Delgado Provinces. Although activity data has been collected for all years in the period from 2001 to 2016, only activity data for the period 2003-2013 was considered for the FREL.

6.2 FREL validity period

The FREL will be valid for 10 years. However, the FREL will be updated as new information becomes available, such as activity data for forest degradation, data on other carbon pools, data on fires and others. It is currently planned to conduct a reevaluation of the 4x4 km grid at the mid-point of the FREL, corresponding to the period between 2013-2018.

7 Methodological choices

7.1 Approach to set FREL/FRL

The FREL/FRL is based on a historical average during the defined reference period. Based on the data collected, there is no trend observed in terms of deforestation (and enhancement of carbon stocks), and it is expected that the national circumstances will not change significantly with regard to the reference period. Therefore, the historical average is deemed as a good proxy of future GHG emissions.

7.2 IPCC methods used

In accordance with the UNFCCC decisions, the FREL was developed following the rules and methods proposed by the 2006 IPCC Good Practice Guidelines for National Greenhouse Gas Inventories. Annual GHG emissions or removals over the reference period in the region of interest ($FREL$) are estimated as the sum of annual change in total carbon stocks over the reference period in the Accounting Area ($\Delta \boldsymbol{C_B}$)

$$FREL \quad = \sum_{t} (\Delta \boldsymbol{C_B})$$

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

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$ **Equation 1**

Where:

ΔC_B	Change of total carbon stocks during the reference period, in tC per hectare, per year.
ΔC_G	Annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tC per hectare and year;
$\Delta C_{CONVERSION}$	Initial change in carbon stocks in biomass on land converted to other land-use category, in tC per hectare and year;
ΔC_L	Annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tC per hectare and year.

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document for applying IPCC Guidelines and guidance in the context of REDD+[6], the above equation will be simplified and it will be assumed that:

- The annual change in carbon stocks in biomass (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$);
- It is assumed that the biomass stocks immediately after conversion is the biomass stocks of the resulting land-use, so ΔC_G and ΔC_L are equal to zero.

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

$$\Delta C_B = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) x\; CF\; x \frac{44}{12} \times A(j,i)$$ **Equation 2**

[6] https://www.reddcompass.org/documents/184/0/MGD2.0_English/c2061b53-79c0-4606-859f-ccf6c8cc6a83

Where:

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

- **Broadleaved (Semi-) deciduous including Miombo to Non Forest;**
- **Broadleaved (Semi-) evergreen to Non-Forest;**
- **Mangrove to Non-Forest;**
- **Mecrusse to Non-Forest;**
- **Mopane to Non-Forest**

$B_{Before,j}$ — Total biomass of forest type j before conversion, in tonne of dry matter per ha. This is equal to the sum of aboveground biomass and below ground biomass of the following five types of forest:

- **Broadleaved (Semi-) deciduous including Miombo;**
- **Broadleaved (Semi-) evergreen;**
- **Mangrove;**
- **Mecrusse;**
- **Mopane;**

$B_{After,i}$ — Total biomass of non-forest type i after conversion, in tonnes dry matter per ha. **This is assumed to be zero in this submission**.

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

- **0.45** is the default set nationally in Mozambique, based on the 2003 IPCC LULUCF GPG

$44/12$ — Conversion of C to CO2

8 Activity Data

8.1 Source

Activity data used for the construction of Mozambique's FREL were obtained from an annual historical time series analysis of land use, land-use change and forestry (LULUCF) carried out by the MRV Unit for the period of 2001 – 2016, using the Collect Earth Open tool. However, these activity data for the construction of Mozambique's FREL were adjusted to the period of 2003 – 2013 filtering out the years that are of interest.

Activity data have been generated following IPCC Approach 3 for representing the activity data as described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 4, Chapter 3, Section 3.13), i.e., using spatially-explicit observations of land-use categories and land-use conversions over time, derived from sampling of geographically located points. Following this approach, a systematic 4 x 4 km grid sampling at national level (the same grid used to allocate the NFI clusters from the Stratified Random Sampling design) was used to generate the national annual historical activity data for the entire area of the country. The result was forest cover data for 2016 and forest cover change data for every year from 2001 to 2016.

8.2 Sampling design

A systematic 4 x 4 km grid consisting of a total of 48 894 points was established at a national level to generate the historical activity data. Each point was visually evaluated and its information was collected and entered in a complete database on LULC changes at the national level.

Therefore, a **systematic sampling design** was established nationally which allows to estimate the variable of interest using accepted unbiased estimators. However, we must remind that the main drawback of systematic sampling is the absence of an unbiased estimator for the variance. Then the variance estimation formulae for random sampling are used as a conservative option. This, generally, overestimates the variance and the overestimation is much more for denser grids).

8.3 Response design

8.3.1 Spatial sampling unit

The spatial sampling unit from each point was defined as a 100m x 100m plot (1 ha), where an internal grid of 5 x 5 points (20m x 20m grid) is overlapped. Each point from the internal grid has a weight coverage of 4%.

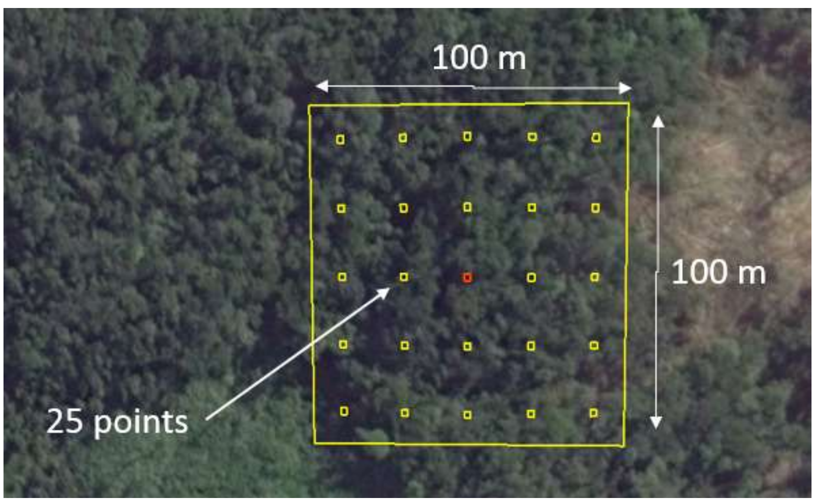

Figure 2. Image of the spatial sampling unit

8.3.2 Source of reference data

The sampling approach for national historical AD calculation based on the systematic 4 x 4 km grid sampling has been designed and conducted using the high and medium resolution image repository available through Google Earth, Bing Maps and Earth Engine Explorer and Code Editor as a visual assessment exercise. These imagery with the forms designed to collect the LULC information on the points of the grid (described in Annex 1) (Figure 2) are automatically accessible through the Collect Earth tool (www.openforis.org) along with scripts accessible through Earth Engine Code Editor that facilitate vegetation type's interpretation and the determination of LULC changes. Specifically; the MOD13Q1 (NDVI 16-day Global Modis 250 m) graphic from 2001-2016, most recent Sentinel-2 image, most recent Landsat-8 pan sharpened image, Landsat-7 pan sharpened image (2000, 2004, 2008, 2012), etc.. Additional, the Earth Engine (Explorer and Code Editor) ensures the completeness of the series through RS products from medium resolution imagery repositories from 2001 (e.g.

Annual TOA Reflectance Composite, Annual NDVI Composite, Annual EVI Composite, Annual Greenest-Pixel TOA Reflectance Composite, etc. from Landsat 5 TM) and the most recent Sentinel-2 image from 2016.

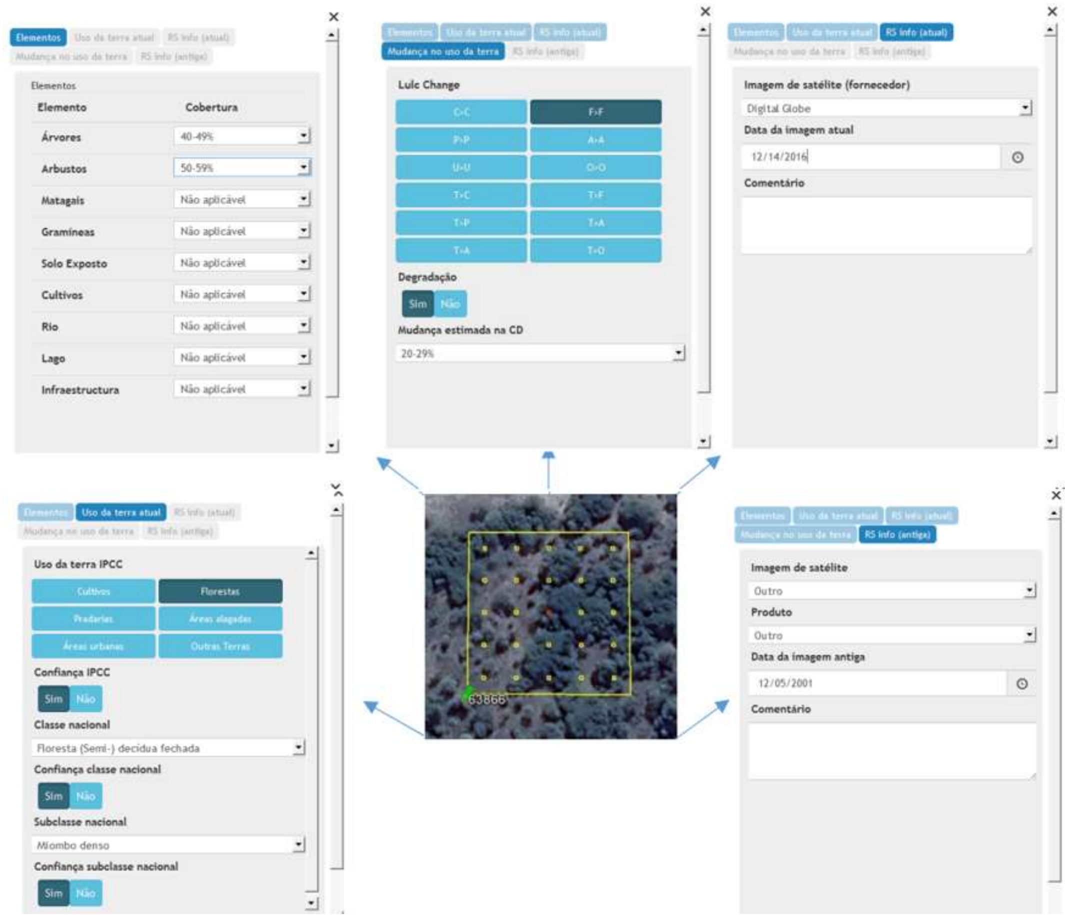

Figure 3. LULC changes detection using Collect Earth Tool. (www.openforis.org). Forms designed with Collect Tool.

8.3.3 Reference labelling protocol

Since a good coverage of very high resolution imagery exists in Mozambique, the classification was based on objects rather than pixel information. In this case, the 25 points of the grid of each sampling unit were evaluated to confirm the object they fall on, and a set of hierarchical rules were set to decide the land use land cover class. The historical activity data was carried out considering the land use and land cover classification system described in Table 1.

Figure 4. A temporal analysis of LULC changes of one point from national 4km x 4 km grid sampling.

A set of hierarchical rules were established and used to determine the land use category based on a certain percentage and taking into account the forest definition as well. A single land use class is easier to classify, but it becomes challenging when there is a combination of two or more land use classes within the area of interest. Thus, this is where the hierarchical rules are important to determine the land use. Any plot that has 30% of tree canopy is considered a forest, according to the national forest definition, even if it has more than 20% of settlements, agriculture or other land use, the forest has priority.

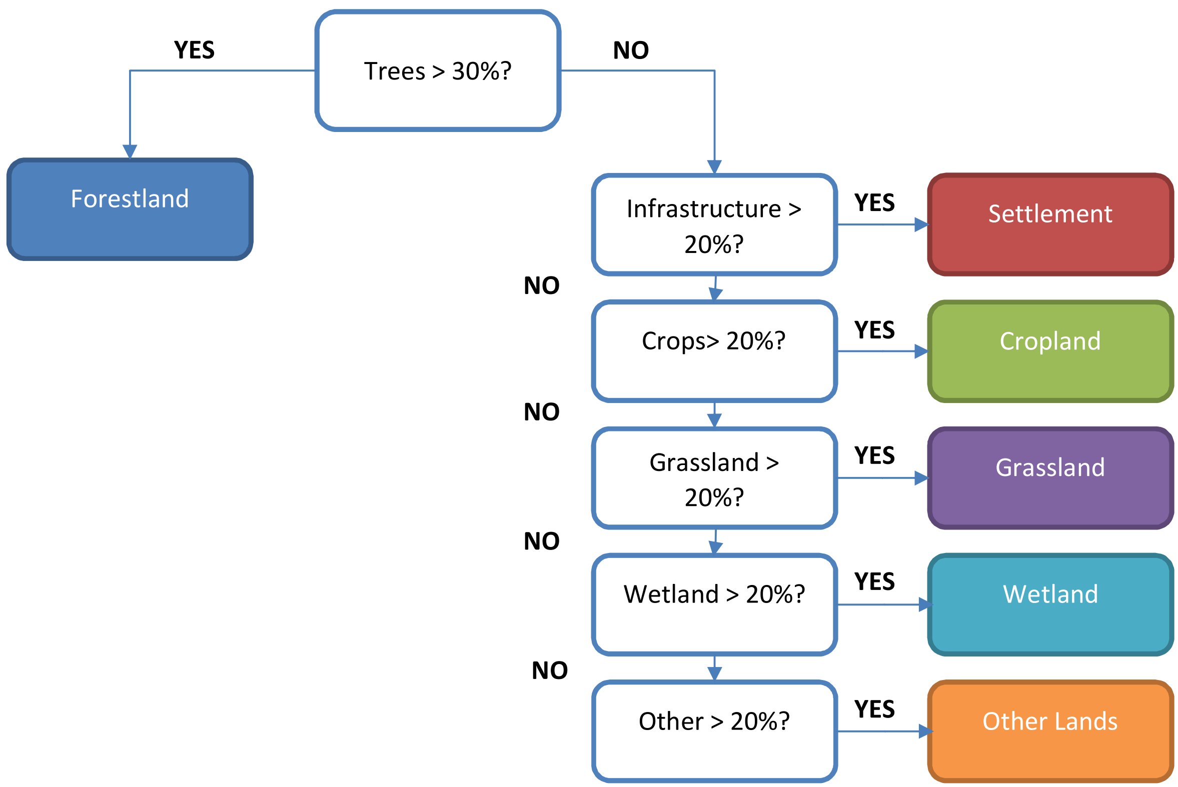

Figure 5. Decision tree for the allocation of the IPCC Land Use category based on the cover of the objects present in the sampling unit

In the case the sampling unit was classified as forestland and different forest types were present in the sample, a majority rule was used in this case, i.e. the largest forest class is the winner.

8.4 Analysis and results

8.4.1 Analysis design

The estimation of the areas corresponding to land-use and land-use changes categories in the framework of this systematic sampling approach (based on the visual assessment of the nodes of a 4 x 4 km national grid) was based on assessments of area proportions. According to 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 4, Chapter 3, Section 3.33), the proportion of each land-use or land-use change category is calculated by dividing the number of points located in the specific category by the total number of points, and area estimates for each land-use or land-use change category are obtained by multiplying the proportion of each category by the total area of interest.

Systematic sampling is generally more efficient than simple random sampling to estimate areas. One-dimensional systematic sampling is optimal if the autocorrelation is positive, decreasing and convex but the main drawback of systematic sampling is the absence of an unbiased estimator for the variance. Then the variance estimation formulae for random sampling are used (2006 IPCC Guidelines for National Greenhouse Gas Inventories, warns that it is an approximate formula). This, generally, overestimates the variance (the overestimation is much more for denser grids), so we can consider the application of this formula as a conservative option (other options are variance estimators that compare each sample element with neighbours, pair differences techniques, etc.).

The standard error (ha) of an area estimate is obtained as (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 3, Section 3.33):

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

$$e = A \times \sqrt{\frac{p_i \times (1 - p_i)}{n - 1}}$$ **Equation 3**

Where:

A	Region of interest, ha.
p_i	Proportion of points on land use change category i, dimensionless.
n	Number of sampling units, number.

The 95% confidence interval for A_i, the estimated area of land-use category *i*, will be given approximately by ±2 times the standard error.

8.4.2 Results for activity data

Figure 6 shows forest losses in Mozambique for the period of 2003 - 2013. Annual areas of forest loss estimated for each type of forest are shown in Table 3 and 4. The annual areas of forest loss estimated for each Province of Mozambique are shown in Annex 2. On average, **267 029** ha/year were deforested between 2003 and 2013. The 95% half width confidence interval of the area of forest loss is ± **12 329** ha/year and the relative margin of error at 95% confidence level is **± 4.6**%.

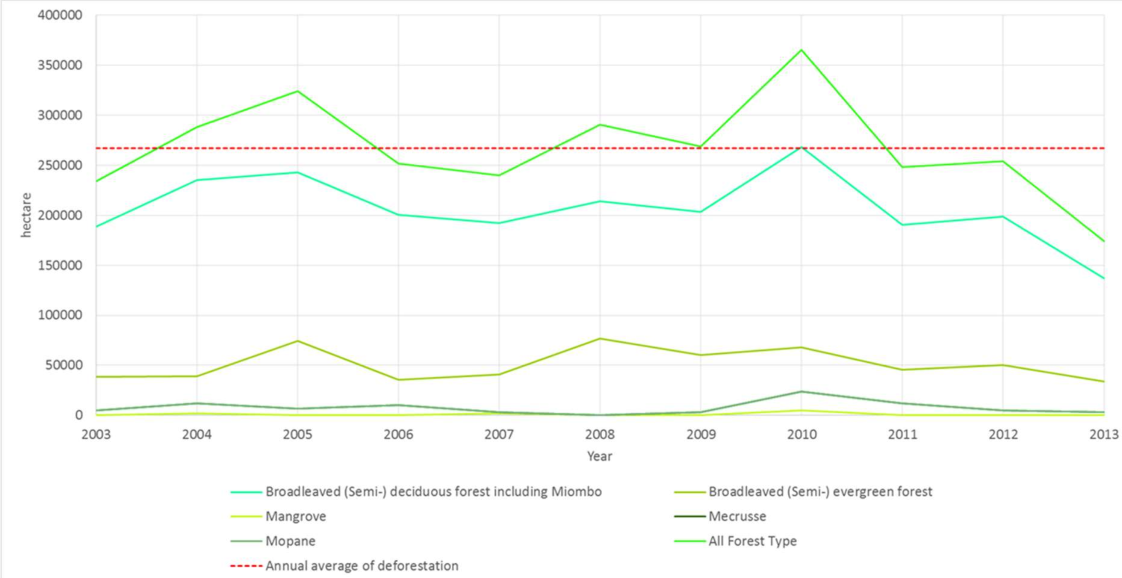

Figure 6. Deforestation in Mozambique between 2003 and 2013

Table 2. Overview of the Land Use, Land Use Change and Forestry (LULUCF) between 2003 and 2013 per forest stratum and forest type

Forest stratum	Deforestation (2003 - 2013)			
	ha	ha/yr	IC (ha/yr)	Error (%)
Broadleaved (Semi-) deciduous forest including Miombo	**2 271 377**	**206 489**	**± 10 894**	**± 5.3**
Miombo open	1 650 990	150 090	± 9 334	± 6.2
Miombo dense	441 785	40 162	± 4 836	± 12.0
Forest with shifting cultivation	178 602	16 237	± 3 101	± 19.1
Broadleaved (Semi-) evergreen forest	**561 665**	**51 060**	**± 5 466**	**± 10.7**
Open broadleaved (Semi-) evergreen mountainous forest	121 430	11 039	± 2 545	± 23.1
Closed broadleaved (Semi-) evergreen mountainous forest	93 000	8 455	± 2 225	± 26.3
Coastal open woody vegetation	11 916	1 083	± 794	± 73.3

Forest stratum	Deforestation (2003 - 2013)			
	ha	ha/yr	IC (ha/yr)	Error (%)
Coastal dense woody vegetation	16 655	1 514	± 949	± 62.7
Gallery forest	318 663	28 969	± 4 129	± 14.3
Mangrove	**8 572**	**779**	**± 671**	**± 86.1**
Mangrove open	3 432	312	± 424	± 136.1
Mangrove dense	5 140	467	± 520	± 111.2
Mopane	**85 283**	**7 753**	**± 2 121**	**± 27.4**
Mopane open	80 150	7 286	± 2 057	± 28.2
Mopane dense	5 133	467	± 520	± 111.4
Mecrusse	**10 425**	**948**	**± 735**	**± 77.6**
Mecrusse open	6 971	634	± 600	± 94.7
Mecrusse dense	3 454	314	± 424	± 135.2
All forest strata	**2 937 322**	**267 029**	**± 12 329**	**± 4.6**

Table 3. Land Use, Land Use Change and Forestry between 2003 and 2013

LULUCF categories	Area (ha)	Standard Error (ha)	Confidence Interval (ha)	Error %
Forest land remaining Forest Land*	34 292 728	183 741	± 360 132.5	± 1.05%
Non-Forest Land converted to Forest Land**	124 393	14 479	± 28 379.3	± 22.81%
Forest Land converted to Non-Forest Land	2 937 322	69 193	± 135 618.8	± 4.62%
Non-Forest Land remaining Non-Forest Land	45 004 433	185 503	± 363 586.8	± 0.81%
Total	**82 358 875**			

** Includes forest plantations*

*** Includes conversion of non-forest land to forest plantations*

9 Emission Factors

9.1 Source

The National Forest Inventory (NFI) is an indispensable tool for generating statistical information about the forest resources of a country. Its data are used to support decision-making on sustainable forest management based on scientific evidence, as well as support from government, private sector, civil society and academia, for a sustainable forestry policy. Mozambique conducted a National Forest Inventory (NFI) from 2015 to 2017. The NFI consisted of two provincial inventories, conducted in the Provinces of Gaza (2015) and Cabo Delgado (2016), as well as a national scale inventory on the remaining eight Provinces of the country (2016-2017). The inventory of the eight Provinces was divided in two phases. The first phase took place in 2016 covering the Provinces of Maputo, Nampula and Inhambane. The second phase took place in 2017 covering the Provinces of Tete, Manica, Sofala, Zambézia and Niassa. There are 46 sampling units that were not measure din the Province of Zambezia and are expected to be measured in 2018.

9.2 Sampling design

The sampling design was initially conceived as a stratified sampling design. The criterion of stratification used in the sampling design was the strata of the agro-ecological zones map of Mozambique, but knowing that the stratification would be replaced by a new stratification once new data on forest area would be available. The number of samples were estimated based on the Coefficients of Variation (CVs) given by the third national forest inventory. The total number of sampling units was 620 units, which were increased by 10% giving a total of 681 units.

N	Strata	Area (ha)	N/ha	AB/ha	Vt/ha	Cv	Supplementary Clusters
1	Semi-deciduous dense forest (+Miombo dense)	7547903	88.2	6.4	60.9	57	**140**
2	Mopane	2183139	77.4	2.8	20.9	50	**108**
3	Semi-evergreen forest (+Gallery Forest)	1662652	91.0	5.2	47.9	50	**107**
4	Mecrusse	526349	58.5	3.1	26.3	40.6	**73**
5	Semi-evergreen mountainous forest	884858	58.3	4.0	39.2	38.4	**64**
6	Semi-deciduous open forest (+Miombo open + Tree savanna)	29725985	81.9	4.3	33.3	71.9	**99**

N	Strata	Area (ha)	N/ha	AB/ha	Vt/ha	Cv	Supplementary Clusters
7	Semi-evergreen open forest	2421296	73.6	3.4	24.8	68.3	**90**
	Total	**44,952,183**					**681**

Later on the random locations were selected out from sven strata of the agro-ecological zones map of Mozambique:. The sample locations were later displaced to the closest point of the national 4x4 grid so as to allow geographical overlap between the national grid used to obtain the land cover information and the ground data.

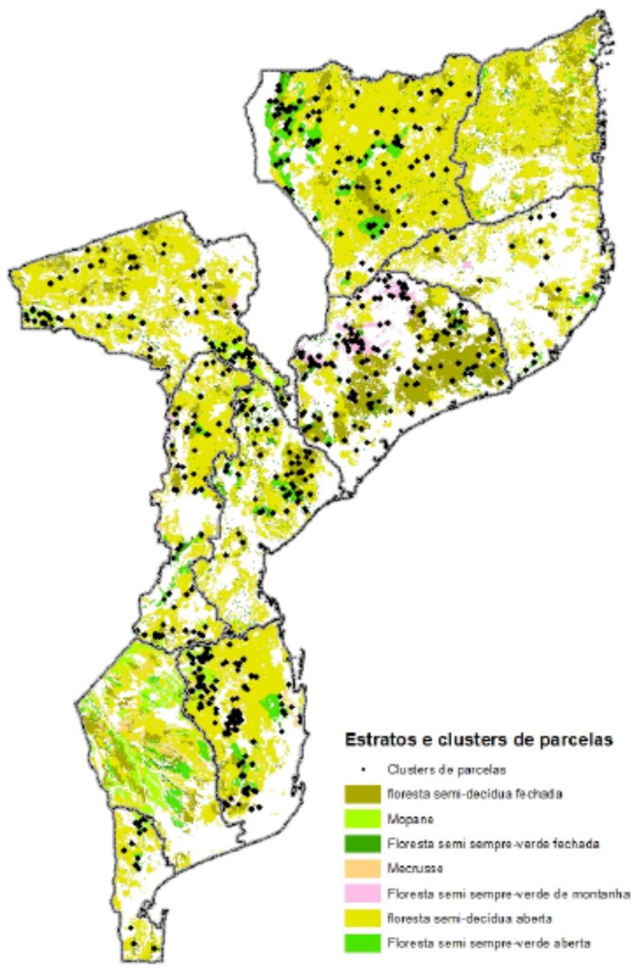

Figure 7. Sampling locations of the NFI. The maps lacks the samples of Cabo Delgado and Gaza.

The provincial inventories of Cabo Delgado and Gaza followed a similar approach as shown above. The combination of all sampling units give a total of 855 sampling units distributed across all Provinces as shown below (in the Table 4).

Table 4. Distribution of the Number of samples of NFI per Province

Province	Number of samples
Maputo	12
Gaza	129
Inhambane	128
Manica	57
Sofala	66
Tete	70
Zambézia	102
Nampula	19
Cabo Delgado	161
Niassa	111
Total	**855**

9.3 Data collection

Each sampling unit was composed by a cluster of four plots located following the scheme shown in Figure 7. Each plot includes a number of quadrants. The trees with DBH greater than or equal to 5 cm were measured in the subplot (Block A) and the equal or greater than 10 cm were measured in the other blocks. The standing trees whose centers are within the plot were measured and recorded. Different procols were followed to collect data on other carbon pools. The complete protocol of data collection is publicly available[7].

[7] http://www.redd.org.mz/uploads/SaibaMais/ConsultasPublicas/Mozambique%20National%20Forest%20Inventory%20Guidelines.pdf.

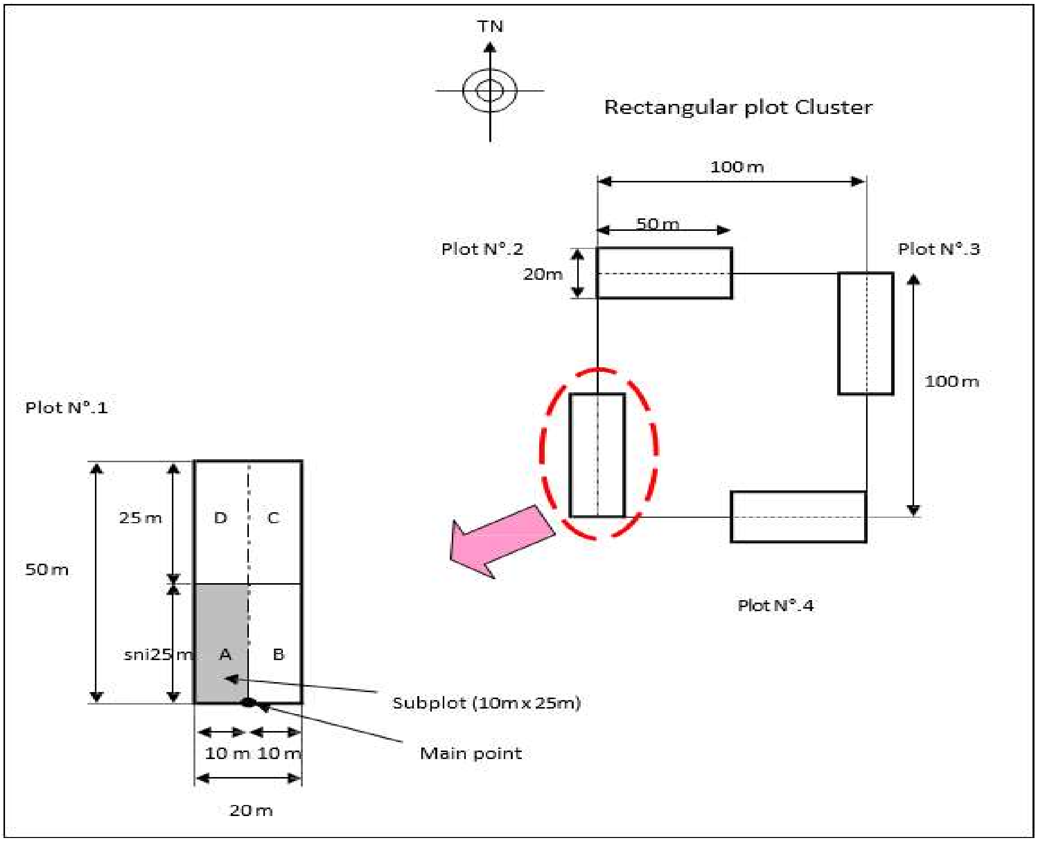

Figure 8. National Forest Inventory plot layout.

9.4 Estimation

Within each plot, trees with DBH ≥ 10 cm were measured for DBH and height. Trees with DBH between 5 and 10 cm were measured for DBH and height in the left bottom subplot of each plot. Tree level above- and belowground biomasses were estimated using the equations indicated in the Table 7 (most of them country-specific). Carbon stored in biomass was obtained as half of the dry mass (biomass), i.e. it was assumed that 50% of the dry mass was carbon (IPCC 2003, Elias & Potvin 2003).

Table 5. Models used to estimate biomass of each stratum and species.

Stratum/species	AGB	BGB
Mopane	Y = 0.03325 * d ^ 1.848 * h ^ 1.241 (JICA 2017)	Y = 0.09572 * d ^ 1.7969 * h ^ 0.3797 (JICA 2017)
Mecrusse	Y=1.1544 + 0.0398*d^2*h (Magalhães 2015)	Y=0.0185*d^2.1990*h^0.4699 (Magalhães, 2015)
Semi-deciduous forest (+ Miombo)	Y=0.0763*d^2.2046*h^0.4918 (Mugaha et al 2013)	Y=0.1766*d^1.7844*h^0.3434 (Mugasha et al 2013)
Semie-evergreen forest (+Gallery)	Y = exp(-2.289+2.649*ln(d)-0.021*(ln(d))^2) (IPCC, 2003)	R/S = 0.28
Milletia stuhlmannii	Y = 5.7332*d^1.4567 (Mate et al 2014)	Y=0.1766*d^1.7844*h^0.3434 (Mugasha et al 2013)
Pterocarpus angolensis	Y = 0.2201*d^2.1574 (Mate et al 2014)	Y=0.1766*d^1.7844*h^0.3434 (Mugasha et al 2013)
Afzelia quanzensis	Y = 3.1256*d^1.5833 (Mate el al 2014)	Y=0.1766*d^1.7844*h^0.3434 (Mugasha et al 2013)

Where AGB is aboveground biomass, BGB belowground biomass, d diameter at breast height (DBH), R/S root-shoot ratio. Note that for Miombo and Mecrusse species occurring in Mopane stratum, models by Mugasha *et al.* (2013) and Magalhães (2015) were used to estimate biomass; however for other non-mopane species the model by IPCC (2003) was applied. The same principle was applied for tree species of a specific stratum occurring in another stratum (e.g. Mecrusse and Mopane species occurring in Miombo, Miombo and Mopane species occurring in Mecrusse).

9.5 Analysis and results

9.5.1 Analysis

Although the sampling design was conceived as a stratified random sampling, this was based on the stratification provided by the agroecological zoning which was not accurate so it was foreseen to replace the stratification by a novel one using latest available data which is more accurate. Therefore, a post-stratified design is applied for the analysis where the stratification is given by the proportions of each forest type provided by the national grid. The provinces of Gaza and Cabo Delgado were not considered as separate strata.

Moreover, although the cluster was conceived as the sampling unit, it was observed that a significant number of clusters had theirs plots lying in different strata. Therefore, the plots were considered to be independent and all the computation was carried out using the plots as sampling units instead of clusters. Table 6 shows the number of plots allocated to each stratum, along with the area of each stratum.

Table 6. Area, proportion and sample size per stratum

Stratum	Area (ha)	Proportion of total area (ph)	Number of plots (nh)
Mopane forest	3 148 377	0.098	401

Stratum	Area (ha)	Proportion of total area (ph)	Number of plots (nh)
Mecrusse forest	902 568	0.028	282
Semi-deciduous forest (+ Miombo)	21 151 847	0.657	1 973
Semi-evergreen forest (+ Gallery)	6 999 749	0.217	764
Total	**32 202 544**	**1**	**3 420**

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

$$\hat{\mu}_{STR} = \sum_{h}^{H} W_h \hat{\mu}_h$$ **Equation 4**

Where:

W_h Weight per stratum h, dimensionless.

$\hat{\mu}_h$ Sample estimates within stratum *h* which is equal to $\hat{\mu}_h = \frac{1}{n_h}\sum_{k=1}^{n_h} y_{hk}$ where y_{hk} is the i^{th} sample observation in the h^{th} stratum

The 95% relative margin of error would be estimated with the following equations which correspond to the variance estimator of a stratified sampling design. This formulae has been used instead that of a post-stratified estimator:

$$Error_{95\%} = 2 \cdot \sqrt{\widehat{Var}(\hat{\mu}_{STR})}$$ **Equation 5**

Where:

$\widehat{Var}(\hat{\mu}_{STR})$ variance of the stratified estimate.

$\hat{\mu}_h$ Sample estimates within stratum *h* which is equal to $\hat{\mu}_h = \frac{1}{n_h}\sum_{k=1}^{n_h} y_{hk}$ where y_{hk} is the i^{th} sample observation in the h^{th} stratum

The variance of the stratified estimate is estimated as follows:

$$\widehat{Var}(\hat{\mu}_{STR}) = \sum_{h}^{H} W_h^2 x \hat{\sigma}_h^2$$

Where:

W_h Weight of stratum *h*;

$\hat{\sigma}_h^2$ Sample variance estimates within stratum *h* which is equal to $\hat{\sigma}_h^2 = \frac{1}{n_h - 1}\sum_{k=1}^{n_h} \hat{\mu}_h * (1 - \hat{\mu}_h)$ where $\hat{\mu}_h$ is the sample estimates within stratum h.

Calculations may be found in the spreadsheet that is provided together with this submission.

9.5.2 Results

Results are provided in the following tables.

Table 7. Above-ground biomass (AGB), above-ground carbon (AGC) and carbon dioxide equivalent or emission factor for AGB (CO2eq (A))

Stratum	AGB [t ha $^{-1}$] (IC)	AGC [t ha $^{-1}$] (IC)	$CO_2eq_{(A)}$ [t ha $^{-1}$] (IC)
Mopane	44.51 (40.65 – 48.36)	20.92 (19.11 – 22.73)	76.71 (66.87 – 83.34)
Mecrusse	78.65 (73.18 – 84.12)	36.97 (34.39 – 39.54)	135.54 (126.11 – 144.97)
Semi-deciduous forest including Miombo	62.24 (59.51 – 64.97)	29.25 (27.97 – 30.54)	107.26 (102.56 – 111.96)
Semi-evergreen forest including gallery forest	99.89 (93.98 – 105.81)	46.95 (44.17 – 49.73)	171.26 (161.96 – 182.35)
Population	69.15 (66.91 – 71.39)	32.50 (31.45 – 33.55)	119.17 (105.31 – 123.03)

Table 8. Below ground biomass (BGB), below ground carbon (BGB) and carbon dioxide equivalent or emission factor for BGB (CO2eq (B))

Stratum	BGB [t ha $^{-1}$] (IC)	BGC [t ha $^{-1}$] (IC)	$CO_2eq_{(B)}$ [t ha $^{-1}$] (IC)
Mopane	13.89 (12.83 – 14.95)	6.53 (6.03 – 7.02)	23.93 (22.11 – 25.76)
Mecrusse	20.58 (19.21 – 21.96)	9.67 (9.03 – 10.32)	35.47 (33.11 – 37.84)
Semi-deciduous forest including Miombo	24.82 (23.88 – 25.75)	11.66 (11.23 – 12.10)	42.77 (41.16 – 44.37)
Semi-evergreen forest including gallery forest	29.19 (27.53 – 30.86)	13.72 (12.94 – 14.50)	50.31 (47.44 – 53.18)
Population	24.58 (23.86 – 25.30)	11.55 (11.21 – 11.89)	42.36 (41.12 – 43.60)

Table 9. Total tree biomass (TB = AGB + BGB), total tree carbon (TC = AGC + BGC) and carbon dioxide equivalent or emission factor for TB (CO2eq (T))

Stratum	TB [t ha $^{-1}$] (IC)	TC [t ha $^{-1}$] (IC)	$CO_2eq_{(T)}$ [t ha $^{-1}$] (IC)
Mopane	58.40 (53.50 – 63.29)	27.45 (25.14 – 29.75)	100.64 (99.20 – 109.08)

Stratum	TB [t ha⁻¹] (IC)	TC [t ha⁻¹] (IC)	$CO_2eq_{(T)}$ [t ha⁻¹] (IC)
Mecrusse	99.23 (92.40 – 106.07)	46.64 (43.43 – 49.85)	171.01 (159.24 – 182.79)
Semi-deciduous forest including Miombo	87.05 (83.40 – 90.70)	40.92 (39.20 – 42.63)	150.02 (143.74 – 156.31)
Semi-evergreen forest including gallery forest	129.09 (121.52 – 136.65)	60.67 (57.11 – 64.23)	222.46 (209.42 – 235.50)
Population	93.73 (90.78 – 96.68)	44.05 (42.67 – 45.44)	161.53 (156.44 – 166.61)

In addition to forest strata mentioned above, this FREL includes mangrove stratum. For this stratum there isn't sufficient information available on above- and below-ground biomass, so were applied the default values of IPCC Guidelines for national greenhouse gas inventories as shown in Table 11. In the future, these values should be replaced with the country specific values.

Table 10. Above- and below-ground biomass in mangroves

Domain	Region	Above-ground biomass ($tDM.ha^{-1}$)	Ratio of below-ground biomass to above-ground biomass		Source
			tonne root d.m. (tonne shoot d.m.)-1	tDM.ha -1	
Tropical	Tropical Wet	92	0.29	26.68	IPCC (2013)

Table 11. Standard error and sampling error of estimates

Error	Stratum	AGB/AGC/$CO_2eq_{(A)}$	BGB/BGC/$CO_2eq_{(B)}$	TB/TC/$CO_2eq_{(T)}$
Standard Error [%]	Mopane	4.42	3.88	4.28
	Mecrusse	3.55	3.41	3.51
	Semi-deciduous forest including Miombo	2.24	1.92	2.14
	Semi-evergreen forest including gallery forest	3.02	2.91	2.99
	Population	1.66	1.50	1.61
Sampling Error [%]	Mopane	8.65	7.61	8.39
	Mecrusse	6.96	6.68	6.88
	Semi-deciduous forest including Miombo	4.39	3.76	4.19

Error	Stratum	AGB/AGC/C $O_2eq_{(A)}$	BGB/BGC/C $O_2eq_{(B)}$	TB/TC/C $O_2eq_{(T)}$
	Semi-evergreen forest including gallery forest	5.92	5.70	5.86
	Population	3.25	2.93	3.15

10 Forest Reference Level

10.1 National circumstances

Mozambique recorded very high deforestation (detailed in Annex 2) between 2003 and 2013, with 0.79% of the forest area being lost annually, which corresponds to 267 029 hectares per year.

10.2 Calculation

Mozambique's FREL has been estimated as the average annual GHG emissions from deforestation of the historical reference period of 2003-2013, aggregating the class of forest in stratum. Calculation methods are provided in section 7.2 and the calculations are provided in the spreadsheet that is provided together with this submission.

Table 12. Calculation of FREL.

Stratum	(ha/year	AGB before (tdm/ha)	BGB before (tdm/ha)	CF, tonne C (tonne d.m.)-1.	Conversion	tCO2/year
Broadleaved (Semi-) deciduous including Miombo	206,489	62.2	24.8	0.5	3.67	32,957,683
Broadleaved (Semi-) evergreen	51,060	99.9	29.2	0.5	3.67	12,083,279
Mangrove	779	92.0	26.7	0.5	3.67	169,554
Mecrusse	948	78.7	20.6	0.5	3.67	172,415
Mopane	7,753	44.5	13.9	0.5	3.67	830,083
TOTAL						**46,213,014**

10.3 Proposed FREL

The FREL estimate for Mozambique was based on the historical average of deforestation for the period 2003-2013 using national emission factors, obtained from the National Forest Inventory for deforestation. According to the table below (table 13 and figure 6), the annual and total of the period emissions are in the order of **46 213 014** tCO2 Eq and **508 343 155** tCO2 Eq, respectively. In the table below, we present the FREL proposal for Mozambique for REDD + activity (deforestation).

Table 13. Total and annual average of emissions of C02 per stratum per year (FREL)

Stratum	Total tCO2	tCO2/year
Broadleaved (Semi-) deciduous including Miombo	362 534 513	32 957 683
Broadleaved (Semi-) evergreen	132 916 066	12 083 279
Mangrove	1 865 095	169 554
Mecrusse	1 896 565	172 415
Mopane	9 130 916	830 083
TOTAL	508 343 155	46 213 014

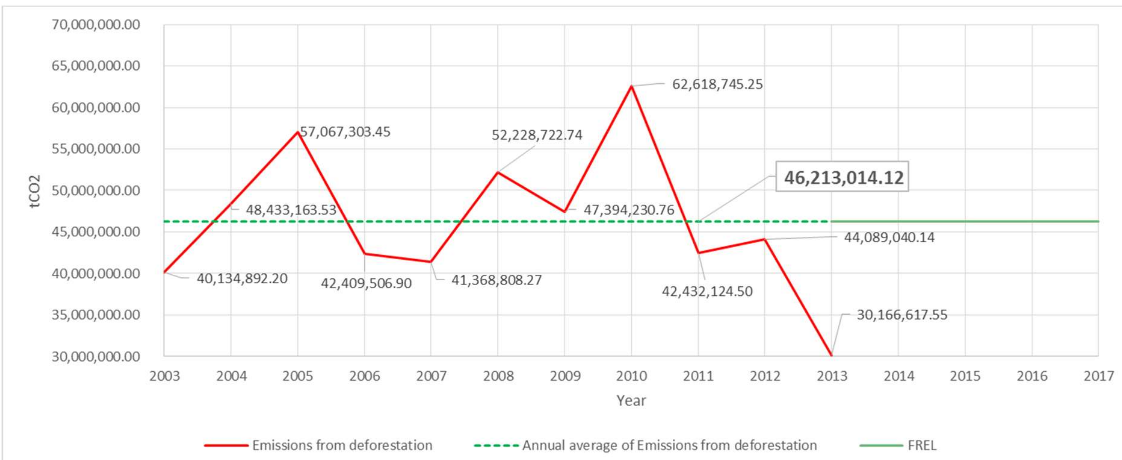

Figure 9. Graphical representation of emission from deforestation per year

10.4 Analysis of uncertainty

Sampling uncertainty was estimated for both activity data and emission factors as shown in sections 9.4 and 10.5. Uncertainties were propagated using the Tier 1 method of the 2006 IPCC GL, i.e. propagation of uncertainties. The following equations were used for addition or multiplication.

For addition or subtraction:

$$U_{total} = \frac{\sqrt{(U_1.x_1)^2 + (U_2.x_2)^2 + \cdots + (U_n.x_n)^2}}{|x_1 + x_2 + \cdots + x_n|}$$ **Equation 6**

Where:

U_i	Percentage uncertainty associated with each of the parameters
X_i	The value of the parameter
U_{total}	The percentage uncertainty in the sum of parameters

For multiplication:

$$U_{total} = \sqrt{U_1{}^2 + U_2{}^2 + \cdots + U_n{}^2}$$

Where:

U_i	Percentage uncertainty associated with each of the parameters

X_i	The value of the parameter
U_{total}	The percentage uncertainty in the multiplication of parameters

Using these equations and the uncertainties reported previously, the uncertainty of the total emissions for deforestation is a 95% confidence interval of ±6% as shown in table 14.

Table 14. Uncertainty per stratum

Stratum	Uncertainty from emission
Broadleaved (Semi-) deciduous including Miombo	7%
Broadleaved (Semi-) evergreen	12%
Mangrove	86%
Mecrusse	78%
Mopane	28%
TOTAL	6%

11 Improvement plan

11.1 Capacity building needs

The Government of Mozambique is as a result of the implementation of the National REDD+ strategy engaging different institutions in measuring and monitoring deforestation and forest degradation. There are some gaps identified that needs urgently to be addressed which are:

- Institutional coordination
- Development of methodologies and guidelines for monitoring GHG's
- Improvement of methodologies to estimate carbon
- Improvement of methodologies for quality control and quality assurance
- Inclusion of additional carbon pool in the estimation of carbon stocks

Institutional coordination is the main challenge for the M&MRV system for REDD+ as those with mandate in monitoring and measuring the carbon from REDD+ are not communicating effectively. It has been identified that some them are carrying the same activities that could be simplified if only one could do while others could do other activities. The main challenge is in the improvement of communication between them to reduce duplication of efforts. This intent will be achieved through memorandums of understanding, workshops for data sharing, production of papers, and harmonization of methodologies between institutions involved on the MRV system.

11.2 Areas of improvement

The following areas of improvement have been identified and will be addressed in the coming years:

- **Forest degradation:** It is expected that Mozambique will develop the methodology to calculate emissions from forest degradation throughout 2018. The country will develop an automated method to produce yearly forest biomass, biomass change and degradation maps for the periods 2007-2010 and 2015-2016, using the freely available ALOS PALSAR (1 and 2) mosaics. This will allow us to produce a benchmark for forest biomass and degradation estimates baseline.
- **Carbon pools:** SOC and DOM data collected during the NFI is still being processed. Once it is finalized, the FREL can be updated with these values.
- **Allometric equations:** We expect that the research institutions of Mozambique will continue developing and improving the allometric equations for different forest strata and species. Thus, updates to this FREL will include new equations developed, especially in the case where a generic equation was used.
- **Emission factors:** The 4th National Forest Inventory produced the emission factors used in this FRELs. It is expected that the National Permanent Sampling Plot Network will allow the updating of emission factors for different strata.
- **Emissions from fires:** Fires are very ubiquitous in Mozambique, and thus it is important to include information on the emissions resulting from fires. Although the MODIS sensor offers easy to use fire products, there is a limitation of insufficient validation data for these products. We plan on conducting a validation process to determine the suitability of these products for the purpose of calculating emissions from fires in Mozambique.

12 References

CEAGRE, & Winrock International. 2016. Estudo sobre causas directas e indirectas do desmatamento e degradação florestal em Moçambique - Relatório final. In (p. 36 p). Maputo, Mozambique.

IPCC, In: Penman J, Gytarsky M, Hiraishi T, Krug T, Kruger D, Pipatti R, Buendia L, Miwa K, Ngara T, Tanabe K, Wagner F (Eds.) 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry. IPCC/IGES, Hayama.

IPCC. 2013. 2013 Supplement to the 2006 IPCC guideline for national greenhouse gas inventories: Wetlands. IGES. Hayama, Japan.

M. Elias, C. Potvin. 2003. Assessing inter- and intra-specific variation in trunk carbon concentration for 32 Neotropical tree species, Can. J. For. Res. 33 1039–1045.

Magalhães T.M. 2015. Allometric equations for estimating belowground biomass of Androstachys johnsonii Prain. Carbon Balance and Management 10:16.

Magalhães T.M. 2015. Live above- and belowground biomass of a Mozambican evergreen forest: a comparison of estimates based on regression equations and biomass expansion factors. Forest ecosystems 2:28.

Mate R.S., Johansson T. 2014. Biomass Equations for Tropical Forest Tree Species in Mozambique. Forests 5: 535-556.

Mokany K., Raison J.R., Prokushkin A.S. 2006. Critical analysis of root: shoot ratios in terrestrial biomes. Global Change Biology 12: 84-96.

Sitoe, A., Salomão, A., & Wertz-Kanounnikoff, S. 2012. The context of REDD+ in Mozambique: Drivers, agents and institutions. Bogor, Indonesia: Center for International Forestry Research (CIFOR)

ANNEX

Annex 1. LULC classification system

The 2006 IPCC Guidelines considers the following land-use categories for greenhouse gas inventory reporting:

- Forest Land: This category includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but in situ could potentially reach the threshold values used by a country to define the Forest Land category.
- Cropland: This category includes cropped land, including rice fields, and agroforestry systems where the vegetation structure falls below the thresholds used for the Forest Land category.
- Grassland: This category includes rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastoral systems, consistent with national definitions.
- Wetlands: This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.
- Settlements: This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions.
- Other Land: This category includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories

And the following land-use conversions:

FF = Forest Land Remaining Forest Land, LF = Land Converted to Forest Land

GG = Grassland Remaining Grassland, LG = Land Converted to Grassland

CC = Cropland Remaining Cropland, LC = Land Converted to Cropland

WW = Wetlands Remaining Wetlands, LW = Land Converted to Wetlands

SS = Settlements Remaining Settlements, LS = Land Converted to Settlements

OO = Other Land Remaining Other Land, LO = Land Converted to Other Land

Where detailed data about the origin of land converted to a category is available, countries can specify the land-use conversion activity we should define and measure (eg. monitoring and measuring deforestation involves considering: (i) FC: Forest Land to Cropland, (ii) FG: Forest land to Grassland, (iii) FW: Forest Land to Wetland, (iv) FS: Forest Land to Settlements and FO: Forest land to Others), but when applying these land-use category conversions, countries should classify land under end land use category to prevent double counting. If a country's national land-use classification system does not match categories (i) to (vi) as described above, the land-use classifications should be combined or disaggregated in order to represent the categories presented here.

The classification system, consistent with the national FREL and the GHG inventory, should be composed of non-overlapping LULC classes and forest strata, with an independent class for forest systems where cyclical changes in forest cover are present, to be in compliance with both methodological frameworks (FCPF CF and VCS JNR).

The LULC classes used in Mozambique (level 2) and national subclasses (level 3) and their correspondence with the IPCC classes (level 1) are shown in below table.

1A. Land use and Land Cover classification system used in the production of the maps, activity data and national forest inventory.

Level 1		Level 2		Level 3	
Class	Description	Class	Description	Class	Description
Forests	1 ha area with more than 30% canopy cover of trees with at least 3 m in height	Forest Plantation	Forest plantations with exotic species, including pines and eucalyptus.		
		Forest with shifting cultivation	Forest area which contains at least 10% cover of crops.		
		Broadleaved (Semi-) evergreen closed forest	(Semi-) evergreen forest with at least 70% canopy cover.	Coastal dense woody vegetation	Evergreen forests found close to the coast.
				Mangrove dense	Forest type that occurs in the coastal intertidal zone.
				Mecrusse dense	Evergreen forest type characterised by dense stands of *Androstachys johnsonii*
				Gallery forest	Forest type found along rivers or in wetlands.
				Closed broadleaved (Semi-) evergreen mountainous forest	Evergreen forests found above 300 m altitude.
		Broadleaved (Semi-) deciduous closed forest	(Semi-) deciduous forest with at least 70% canopy cover.	Miombo dense	Deciduous forest type characterised by the dominance of *Brachystegia* and *Julbernardia* species.
				Mopane dense	Deciduous forest type characterised by the dominance of *Colophospermum mopane*

Level 1		Level 2		Level 3	
Class	Description	Class	Description	Class	Description
		Broadleaved (Semi-) evergreen open forest	(Semi-) evergreen forest with less than 70% canopy cover.	Coastal open woody vegetation	Evergreen forests found close to the coast.
				Mangrove open	Forest type that occurs in the coastal intertidal zone.
				Mecrusse open	Evergreen forest type characterised by dense stands of *Androstachys johnsonii*
				Open broadleaved (Semi-) evergreen mountainous forest	Evergreen forests found above 300 m altitude.
		Broadleaved (Semi-) deciduous open forest	(Semi-) deciduous forest with less than 70% canopy cover.	Mopane open	Deciduous forest type characterised by the dominance of *Colophospermum mopane*
				Miombo open	Deciduous forest type characterised by the dominance of *Brachystegia* and *Julbernardia* species.
Crops	1 ha area with more than 20% cover of any type of planted crop, but less than 30% cover of forest or 20% cover of infrastructure.	Tree crops	Planted tree crops, including coconut, mango and cashew trees		
		Field crops	Field crops with less than 20% cover of tree crops.	Shrub plantation	Including tea, banana and cane.
				Rainfed crops	Including shifting agriculture.
				Irrigated crops	Including commercial agriculture
				Rice crops	
		Shifting cultivation with open to closed forested areas	Planted crop area with more than 10% forest cover.		

Level 1		Level 2		Level 3	
Class	Description	Class	Description	Class	Description
Grassland	1 ha area dominated by grasses and shrubs or woodlands with less than 30% tree cover. Also less than 20% cover of crops or infrastructure.	Grasslands	Area dominated by grasses, with less than 20% cover of trees or shrubs		
		Thicket	Area with more than 20% cover of shrubs or trees.	Broadleaved (Semi-) evergreen thicket	
			Area with more than 20% cover of shrubs or trees.	Broadleaved (Semi-) deciduous thicket	
		Shrubland	Area with more than 20% cover of shrubs or trees.	Broadleaved (Semi-) evergreen shrubland	
				Broadleaved (Semi-) deciduous shrubland	
Wetlands	1 ha area permanently flooded or temporarily flooded with or without shrubby or herbaceous vegetation.	Aquatic or regularly flooded shrublands	Aquatic or regularly flooded with more than 20% cover of shrubs or trees	Aquatic or regularly flooded shrublands	
		Aquatic or regularly flooded herbaceous vegetation	Aquatic or regularly flooded area dominated by grasses, with less than 20% cover of trees or shrubs	Aquatic or regularly flooded herbaceous vegetation	

Level 1		Level 2		Level 3	
Class	Description	Class	Description	Class	Description
		Artificial water bodies	Artificial water body with less than 20% cover of trees, shrubs or grasses.	Artificial water bodies	
		Natural water bodies	Natural water body with less than 20% cover of trees, shrubs or grasses.	Natural water bodies	
		Salt lake		Salt lake	
Settlements	1 ha area with at least 20% cover of infrastructure (houses, roads, etc), but less than 30% forest canopy cover.				
Other land	Bare area with less than 20% cover of grasses, shrubs, trees, wetland, crops or infrastructure	Bare soils	Bare area consisting of soil	Bare soils	
		Bare rocks	Bare area consisting of rocks	Bare rocks	
		Dunes	Bare area consisting of sand dunes	Dunes	

Annex 2. Activity Data detailed results

2A. Historic of deforestation per Province

Province	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	All Years (2003 - 2013)	
	Hectare											ha	ha/yr
Cabo Delgado	16476	9886	13181	21419	29658	16476	14829	13181	18124	9886	3295	166412	15128
Gaza	7018	12282	3509	15791	3509	1755	1755	10527	7018	3509	3509	70183	6380
Inhambane	10475	6983	15712	8729	3492	1746	3492	1746	5237	3492	3492	64593	5872
Manica	39183	51108	64737	35776	22147	49404	42590	39183	28961	11925	25554	410568	37324
Maputo	3561	0	7122	0	0	1780	0	0	1780	0	1780	16024	1457
Maputo City	0	0	0	0	0	0	0	0	0	0	0	0	0
Nampula	63487	115279	75182	53463	75182	80194	60146	76853	86877	76853	50121	813637	73967
Niassa	19063	17474	31772	23829	23829	36537	36537	82606	30183	50835	31772	384437	34949
Sofala	34173	44425	47843	30756	32465	32465	15378	35882	10252	37591	6835	328064	29824
Tete	15024	10016	11686	5008	6678	15024	16694	33388	21702	15024	16694	166938	15176
Zambézia	25737	20590	53191	56622	42896	54907	77212	72065	37748	44612	30885	516466	46951
Country	234198	288044	323934	251393	239854	290289	268632	365431	247884	253726	173937	2937322	267029

2B. Historic of deforestation per Stratum

Stratum	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total (ha)	ha/yr
Broadleaved (Semi-) evergreen	188 848	235 354	242 940	200 388	192 401	213 758	203 288	268 354	190 519	198 476	137 050	2 271 377	206 489
Broadleaved (Semi-) deciduous including Miombo	38 633	38 874	74 239	35 283	40 605	76 531	60 370	68 104	45 389	50 123	33 514	561 665	51 060
Mangrove	0	1 716	0	0	1 716	0	0	5 140	0	0	0	8 572	779
Mecrusse	1 755	0	0	5 246	1 709	0	1 716	0	0	0	0	10 425	948
Mopane	4 963	12 100	6 754	10 476	3 424	0	3 258	23 831	11 975	5 128	3 373	85 283	7 753
Total	234 198	288 044	323 934	251 393	239 854	290 289	268 632	365 431	247 884	253 726	173 937	2 937 322	267 029

2C. Historic of Emission per Province

Province	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total tCO2	tCO2/year
Cabo Delgado	2 756 740	1 577 886	2 103 848	3 418 753	4 733 658	2 883 669	2 620 688	2 357 707	3 146 650	1 704 815	652 891	27 957 306	2 541 573
Gaza	1 159 335	1 726 731	560 094	2 098 615	467 903	415 213	280 047	1 219 327	843 615	467 903	695 260	9 934 044	903 095
Inhambane	1 671 851	1 114 568	2 416 049	1 471 112	557 284	278 642	557 284	278 642	835 926	557 284	557 284	10 295 924	935 993
Manica	6 951 901	9 249 004	12 432 491	5 883 118	3 928 575	8 804 125	7 978 957	6 558 181	4 926 710	1 945 111	4 514 126	73 172 299	6 652 027
Maputo	568 342	0	1 136 683	0	0	421 327	0	0	284 171	0	421 327	2 831 850	257 441
Maputo City	0	0	0	0	0	0	0	0	0	0	0	0	0
Nampula	10 174 095	18 785 829	13 029 461	9 048 024	12 514 636	13 700 742	10 629 498	12 910 005	15 282 216	13 553 535	9 029 523	138 657 564	12 605 233
Niassa	3 448 689	3 033 847	5 682 966	4 292 819	4 048 061	5 831 731	6 482 536	14 898 090	5 062 275	8 847 987	5 438 208	67 067 210	6 097 019
Sofala	6 244 181	7 659 092	8 820 831	5 567 111	6 272 844	7 156 130	2 981 000	7 010 842	1 899 580	7 052 881	1 090 880	61 755 372	5 614 125
Tete	2 655 251	1 768 188	1 602 001	799 348	1 106 686	2 783 854	2 576 779	4 627 269	3 200 697	2 310 329	2 705 382	26 135 784	2 375 980
Zambezia	4 504 508	3 518 018	9 282 879	9 830 607	7 739 161	9 953 289	13 287 442	12 758 682	6 950 284	7 649 195	5 061 736	90 535 801	8 230 527
Total	**40 134 892**	**48 433 164**	**57 067 303**	**42 409 507**	**41 368 808**	**52 228 723**	**47 394 231**	**62 618 745**	**42 432 125**	**44 089 040**	**30 166 618**	**508 343 155**	**46 213 014**